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ABSTRACT

This guide contains instructor's materials for teaching a secondary agricultural construction course consisting of instructional units on arc welding (8 lessons) and project construction (14 lessons). The materials for each unit include student objectives, a list of competencies from which the objectives were derived, suggestions for motivating students to study the unit, lists of references for the student and teacher, a competency profile on which student performance can be recorded, and the lessons. The lessons typically include study questions; student handouts, including job sheets and work sheets; questions to be used to evaluate student performance; teaching procedures, including some content material; and answers to evaluation questions. The appendices contain a checklist for accidents, a sample student accident report form, and software programs on trailer axle placement that can be used an IBM, Radio Shack, and Apple computers. (CML)

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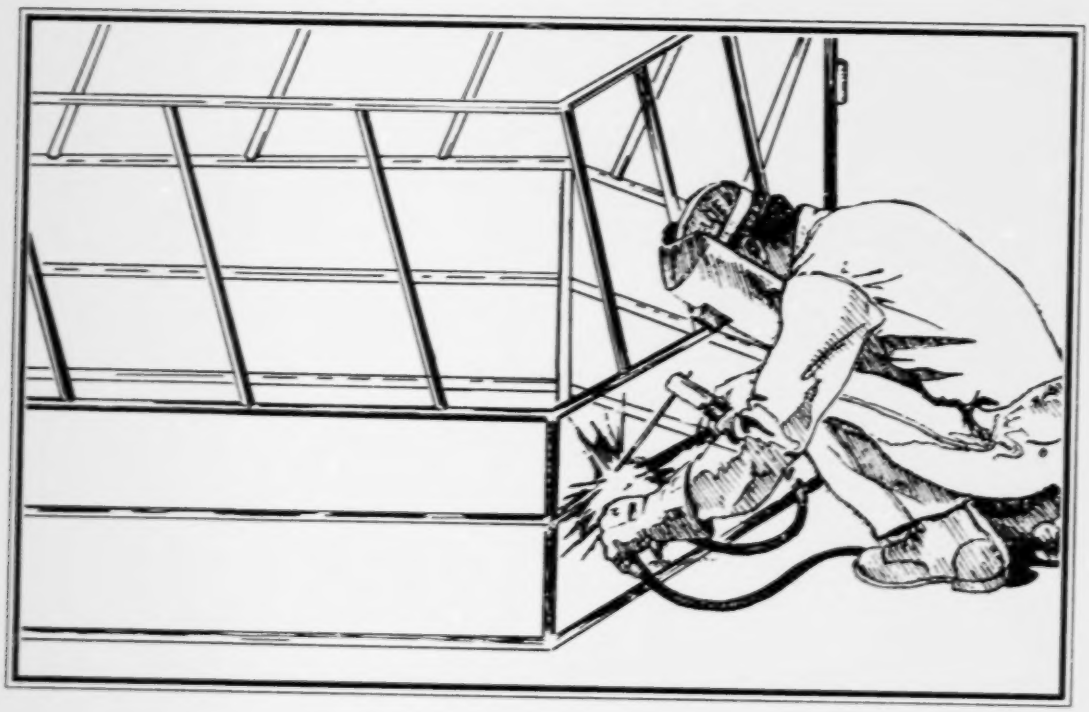
10-7141-I

Agricultural Construction

Volume I

Arc Welding Project Construction



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Instructor's Guide

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AGRICULTURAL CONSTRUCTION (Volume I)

Arc Welding
Project Construction

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FOREWORD

The development of a curriculum guide for agricultural construction was suggested by the MVATA Teaching Aids Committee. The Agricultural Construction Advisory Committee suggested the topics to be discussed and reviewed the materials. This guide, volume I, contains an Arc Welding unit and a Project Construction unit. Volume II, which will be published at a later date, contains units on Oxy-Acetylene and Other Cutting/Welding Processes, Woodworking, Metals, and Finishing. Student handouts have been developed as needed to supplement existing references for each unit.

This guide consists of an Arc Welding unit and a Project Construction unit. Check the Table of Contents for a detailed listing of lessons. The "Contents" section in each unit contains objectives, competencies, references, and a competency profile.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, Dr. Frank Drake, Director of Vocational Education, applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed component parts to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of each unit, as well as being incorporated within each lesson. A competency profile has also been provided in each unit for convenient record keeping.

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OBJECTIVES

1. The student will be able to list the safety precautions for arc welding.

2. The student will be able to identify the various types of metals and their properties.

3. The student will be able to prepare metals for welding by cutting, grinding, and/or cleaning.

4. The student will be able to weld in all positions with the shielded metal arc welder.

5. The student will be able to weld in all positions with the gas metal arc welder.

6. The student will be able to hardsurface areas where extensive wear may occur.

7. The student will be able to weld cast iron with the shielded metal arc welder.

8. The student will be able to weld pipe for agricultural construction and repair.

NOTE: Percent of accuracy should be set by instructors to reflect passing grades within their school systems.

COMPETENCIES

1. List the safety procedures for arc welding.

2. Identify the various types of metal and their properties.

3. Prepare metals for welding by cutting, grinding, and/or cleaning.

4. Weld in all positions with the stick welder (shielded metal arc welder).

   a) Weld in flat position unit 6010 & 7018
   b) Weld in horizontal positions using 6010, 6011, & 7018
   c) Weld in vertical up position using 6010, 6011, & 7018
   d) Weld in vertical down position using 6010 & 6011
   e) Weld in overhead position using 6010, 6011, & 7018

5. Weld in all positions with MIG welder (gas metal arc welding).

   a) Weld in flat position using E-70S-3 & E-71S-3
   b) Weld in vertical position using E-70S-3 & E-71S-3
   c) Weld in horizontal position using E-70S-3 & E-71S-3
   d) Weld in overhead position using E-70S-3 & E-71S-3

6. Hardsurface areas where extensive wear may occur.

7. Weld cast iron.

8. Weld pipe.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. To stimulate students' interest in welding as a career, present the following situation. Jackie is in her second year of agricultural education. Since Jackie enjoys working with metals and welding, she is considering a career in welding. What steps should Jackie take to become a welder? How can she prepare for a welding career now? Where can Jackie find information about the welding industry? What job opportunities might be available in the community?

2. Ask students to list items on the farm or agribusiness that have been welded. As the students discuss the different items, point out the different processes, such as arc welding or MIG welding, that were used to weld the item.

3. Ask the class to identify industries that use arc welding in the fabrication of their products. What different welding processes were used to create the products?

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit. Evaluate students' performance for each weld.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background information acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student References

   a) Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985

   b) Agricultural Construction (Student Handouts). Vol. 1. University of Missouri-Columbia: Instructional Materials Laboratory, 1989.

2. Teacher References

   a) "Agricultural Mechanics I," Agricultural Science I Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

   b) "Agricultural Mechanics II," Agricultural Science II Curriculum. University of Missouri-Columbia: Instructional Materials Laboratory.

   c) Althouse. Modern Welding. Goodheart Publishers.

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   e) Cooper, Elmer L. Agricultural Mechanics: Fundamentals and Applications. Albany: Delmar Publishers Inc., 1987.

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h) Jefferson, T.B. Metals and How to Weld Them. 2nd ed. Cleveland: James Lincoln Arc Welding Foundation.

i) Jeffus, Larry; Harold V. Johnson. Welding Principles and Applications. Albany: Delmar Publishers Inc., 1984.

j) Sosnin, H.A. Arc Welding Instructions for the Beginner (Teachers Manual). Cleveland: James F. Lincoln Arc Welding Foundation, 1964.

k) Squires, William T. Arc Welding. 1st ed. Athens, GA: American Association for Vocational Instructional Materials, 1985.

l) Wakemeir, T.J. Modern Agricultural Mechanics. Danville, IL: Interstate Publishers, 1977.

AGRICULTURAL CONSTRUCTION

UNIT I - ARC WELDING

MAJOR COMPETENCY PROFILE

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect employability readiness rather than the grades given in class.

Rating Scale:

3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N

Arc Welding

*1. List the safety procedures for arc welding.

2. Identify the various types of metals and their properties.

3. Prepare metals for welding: cutting, grinding, and/or cleaning.

4. Weld in all positions with stick welder (Shielded Metal Arc Welding).
   - **a. Weld in flat position using 6010 and 7018.
   - **b. Weld in horizontal position using 6010, 6011, and 7018.
   - **c. Weld in vertical up position using 6010, 6011, and 7018.
   - **d. Weld in vertical down position using 6010 and 6011.
   - **e. Weld in overhead position using 6010, 6011, and 7018.

5. Weld in all positions with MIG welder (Gas Metal Arc Welding).
   - **a. Weld in flat position using E-70S-3 and E71S-3.
   - **b. Weld in vertical position using E-70S-3 and E-71S-3.
   - **c. Weld in horizontal position using E-71S-3 and E-71S-3.
   - **d. Weld in overhead position using E-70S-3 and E-71S-3.

AGRICULTURAL CONSTRUCTION

UNIT I - ARC WELDING cont.

MAJOR COMPETENCY PROFILE

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
- 3 **Mastered** - can work independently with no supervision
- 2 **Requires Supervision** - can perform job completely with limited supervision
- 1 **Not Mastered** - requires instruction and close supervision
- N **No Exposure** - no experience or knowledge in this area

3	2	1	N	Arc Welding cont.
				6. Hardsurface areas where extensive wear may occur.
				7. Weld cast iron.
				8. Weld pipe.
				Other (specify)

***NOTE:** All competencies involving safety require a Number 3 Rating.

****NOTE:** Pass destruction test.

AGRICULTURAL CONSTRUCTION
Unit I: Arc Welding

CLASS/SECTION: _____

STUDENTS:

STUDENTS:	*1. List the safety procedures for arc welding.	2. Identify the various types of metals and their properties.	3. Prepare metals for welding: cutting, grinding, and/or cleaning.	4. Weld in all positions with stick welder (Shielded Metal Arc Welding).	**a. Weld in flat position using 6010 and 7018.	**b. Weld in horizontal position using 6010, 6011, and 7018.	**c. Weld in vertical up position using 6010, 6011, and 7018.	**d. Weld in vertical down position using 6010 and 6011.	**e. Weld in overhead position using 6010, 6011, and 7018.	5. Weld in all positions with MIG welder (Gas Metal Arc Welding).	**a. Weld in flat position using E-70S-3 and E71S-3.	**b. Weld in vertical position using E-70S-3 and E-71S-3.	**c. Weld in horizontal position using E-70S-3 and E-71S-3.	**d. Weld in overhead position using E-70S-3 and E-71S-3.	6. Hardsurface areas where extensive wear may occur.	7. Weld cast iron.	8. Weld pipe.

UNIT I - ARC WELDING

Lesson 1: Safety Precautions for Arc Welding

Objective: The student will be able to list the safety precautions for arc welding.

Study Questions

1. What types of hazards exist for the operator and others during the arc welding process?
2. How can electrical shock be avoided during arc welding?
3. How can burns be avoided during arc welding?
4. How can harmful light rays which result from arc welding be avoided?
5. How can the hazards caused by harmful fumes from welding be limited?
6. What safety practices should be followed to limit the danger of fire when arc welding?
7. What type of clothing and footwear should be worn while welding?
8. What measures should be taken when cleaning the weld?
9. What steps should be taken in case of an accident in the shop area?
10. What dangers exist in cutting or welding used containers?

References

1. Giachino, Joseph W., William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 1.1: Safety Precautions for Arc Welding

UNIT I - ARC WELDING

Lesson 1: Safety Precautions for Arc Welding

TEACHING PROCEDURES

A. Introduction

Introduce the unit. Review the first lesson on arc welding in the Agricultural Mechanics unit of Agricultural Science I and II.

B. Motivation

Staring at a bright light becomes uncomfortable in a matter of minutes. The light from arc welding is more intense than most other lighting. Explain to students how eyes are injured and what they feel like after viewing intense light. View lights using different filtered lenses. Have students describe light intensity and the strain on the eye when viewing intense light.

C. Assignment

D. Supervised study

E. Discussion

1. Arc welding can be hazardous if certain safety considerations are not observed. Discuss with students the types of hazards that exist while arc welding.

   What types of hazards exist for the operator and others during the arc welding process?

   a) Electrical shock
   b) Burns
   c) Harmful light rays
   d) Harmful fumes
   e) Fire

2. One of the biggest safety concerns when arc welding is electrical shock. Discuss with students the procedures to follow to avoid electrical shock when welding.

   How can electrical shock be avoided during arc welding?

   a) Do not lay the electrode holder on a grounded cable.
   b) Do not stand in water or on a wet floor while welding.
   c) Before repairing or adjusting the welder, make sure that the machine is off in two places: the on-off switch and the main switch.
   d) Check the welding cables for damaged insulation or poor connections before welding.
   e) When welding outside, stand on a piece of nonconductive material such as wood.

3. Arc welding requires students to work with a flame and hot metal. Ask students to describe precautions that should be taken to avoid burns while arc welding.

How can burns be avoided during arc welding?

a) Use caution in releasing the ground clamp after welding. It may have become hot during welding because of a poor connection.
b) Do not leave hot metal where others might come in contact with it. If the metal cannot be moved, chalk the word "hot" on it plainly in large letters.
c) Handle hot metal with pliers or tongs, never with a gloved hand.

4. Special equipment is required to avoid injury due to the intense light rays from arc welding. Ask students what they can do to avoid harmful light rays which result from arc welding. Perform the demonstration as suggested in the motivation.

How can harmful light rays which result from arc welding be avoided?

a) Always wear a welding helmet with the proper shade of lens: No. 10 or darker.
b) Always check the helmet and lens for cracks before using.
c) Wear long sleeves and gauntlet-style gloves.
d) Do not leave any skin exposed to rays from the welder.
e) Shout the word, "Cover!" to all people standing nearby when ready to strike the arc.
f) Never look at the arc with an unprotected eye.

5. One of the most overlooked dangers when arc welding is the smoke created during welding. Discuss with students why the fumes are harmful and how they can be removed to provide a safe working environment.

How can the hazards caused by harmful fumes from welding be limited?

a) Do not weld without proper ventilation.
b) Do not weld brass, galvanized, or cadmium-plated metal.
c) Be cautious when welding brazed materials for brazing involves brass.

6. The area around the welding booth can present safety hazards, even though proper welding procedures are followed. Discuss with students the safety practices that should be followed to limit the danger of fire.

What safety practices should be followed to limit the danger of fire when arc welding?

a) Work over concrete or fireproof surfaces.
b) Do not weld when wearing dirty or oil-soaked clothing.
c) Clear the work area of flammable materials before welding.
d) Use a dry chemical fire extinguisher, never water, to put out fires near the welder.
e) Keep the welding booth clean and free of scraps and rubbish.
f) Never weld or heat drums or other containers that have been used for storing gasoline, oil, or similar materials.

7. An important safety consideration for the welder is to protect themselves from light rays and flying sparks. Ask students what type of protective clothing and shoes

should always be worn when welding to guard against rays from the arc and splatter of molten metal.

What type of clothing and footwear should be worn while welding?

a) Clothing should be made of natural fiber such as cotton or wool. Do not wear work clothing made of synthetic fabric.
b) The shirt should be long-sleeved, with collar and sleeves buttoned. Wear cotton shirts and pants.
c) Pants should be cuffless or have cuffs turned down. Do not wear pants with frayed cuffs.
d) Dark clothing is better than light.
e) Welding gloves, preferably leather and gauntlet-type, should be worn.
f) High-top boots provide protection from hot metal. Footwear should be all leather; not cloth. Do not wear tennis shoes.

8. Safety practices do not end when the weld is completed. Discuss the hazards that exist when cleaning a weld. Ask students what measures should be taken when cleaning the weld.

What measures should be taken when cleaning the weld?

a) Wait for the weld to cool.
b) Wear protective clear goggles with side shields.
c) Chip the slag away; do not hammer it off.
d) Strike the bead near the point where the slag meets the metal.
e) Chip the slag away from the body to avoid burns and reduce the change of getting slag in the eyes.

9. The welding shop can be dangerous. Ask students what immediate dangers exist in the welding area. Also discuss what should be done for an injured person. Refer to Appendix A for a checklist of things to do in case of an accident. If your school district does not have an accident form, Appendix B contains a Standard Student Accident form that may be used to document steps taken in case of an accident.

What steps should be taken in case of an accident in the shop area?

a) Notify the instructor of the injury.
b) See the school nurse for treatment.
c) Seek medical attention, if out of school or after hours.

10. Ask students to discuss why workers are injured and/or killed due to explosions caused from welding or cutting near flammable and explosive materials. Discuss with students how these dangers can be eliminated.

What dangers exist when cutting or welding used containers?

a) Do <u>not</u> cut or weld any container which has been used to store combustible or flammable materials. Sparks or flame may cause an explosion.
b) Cut containers with spark-resistant tools (e.g., cold chisels, saber saw).

F. Other activities

1. Construct a bulletin board on welding safety.

2. Construct a display of equipment used in welding for science fair or job fair.

3. Have students prepare written or oral reports on welding safety.

4. Write to the American Welding Society for safety pamphlets on arc welding and oxy-fuel gas welding, cutting, and heating.

5. Check with your local welding equipment/supplies distributor for welding safety films or videos.

G. Conclusion

Because arc welding involves the use of electricity and molten metal, care must be taken to provide a safe work area. Proper personal protective equipment is a must. Proper ventilation is important because of the amount of smoke and fumes. Care must be taken not to weld around combustible or flammable materials or in containers that have been used for storing combustibles.

H. Competency

List the safety procedures for arc welding.

I. Answers to Evaluation

1. d
2. d
3. b
4. e
5. b
6. a
7. c
8. e
9. a
10. a

Name _____

Lesson 1: Safety Precautions for Arc Welding

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Don't make repairs to welding equipment unless the power to the machine is _____.

   a. AC
   b. DC
   c. On
   d. Off
   e. Idling

2. Which of the following materials is unsafe for an individual to stand on or have contact with when welding?

   a. Rubber mat
   b. Plywood
   c. Concrete
   d. Water
   e. Canvas

3. The term used by the welder to warn nearby people of the intense light prior to welding is _____.

   a. "Watch it!"
   b. "Cover!"
   c. "Heads up!"
   d. "Fire!"
   e. "Arc!"

4. What type of fire extinguisher should be used for putting out fires near the electric welder?

   a. Class A
   b. Water
   c. Soda water
   d. Foam
   e. Dry chemical

5. When removing slag from a bead, what type of eye protection should be worn?

   a. Prescription glasses
   b. Safety goggles
   c. No. 6 lens
   d. No. 10 lens
   e. No. 14 lens

6. Which of the following types of clothing is acceptable for safe arc welding?

   a. Cotton clothing
   b. Polyester clothing
   c. Oil-soaked clothing
   d. Light-colored clothing
   e. Tee-shirt

7. Which of the following protective gear should <u>not</u> be included for the welder's safety?

   a. Long-sleeved shirt
   b. Cuffless pants
   c. Street shoes
   d. Gauntlet gloves
   e. Helmet

8. Handle hot metal with _____.

   a. Gauntlet gloves
   b. Rubber gloves
   c. Cotton gloves
   d. Jersey gloves
   e. Pliers

9. What danger exists in cutting a used container with an electrode or torch?

   a. Explosion
   b. Rough cuts
   c. Poor arcing
   d. Worthless containers
   e. Extra rods

10. Following injury caused by ultraviolet light and fumes, a person should _____.

    a. Notify the instructor immediately
    b. Wear sunglasses
    c. Ignore it
    d. Hide it from the instructor
    e. Pretend it didn't happen

The welding area of a shop is a danger zone. The welder and other workers are subject to many types of hazards during the welding process.

Types of Hazards during Arc Welding

Because the arc welding process involves electrical power, the possibility of electric shock exists. The heat of welding is at such a high temperature that metals melt. This heat can easily burn the worker or others if caution is not exercised. Fire is also a possible hazard because of the heat generated in welding. Ultraviolet and infrared light are generated in the welding process. This intense light is harmful to unprotected skin and eyes. The fumes given off in welding are toxic. These poisonous fumes from the burning elements cause considerable damage to a worker's lungs. The worker needs to be aware of the possible hazards of electric shock, burns, harmful light rays, harmful fumes, and fire during welding.

Electric Shock

Several precautions should be taken to avoid electric shock during arc welding. The electrode holder should not be laid on a ground cable. The worker should never stand in water or lie or kneel on a wet floor while welding. Always make sure the machine is off at the machine switch as well as the main power switch. Disconnect the power cord before any adjustment or repair is performed. The welder should check the welding cables for damaged insulation or poor connections before welding begins. If welding is to be done outside, the welder should stand on nonconductive material (such as wood). Avoid welding in damp, sweaty clothing.

Burns

Burns can be avoided during arc welding by carefully releasing the ground clamp after welding. The clamp may become hot during welding if the connection is poor. It is unwise to leave hot metal lying in places where other workers might come in contact with it. Chalk the word 'HOT' onto pieces of metal that cannot be moved. Handle hot metal with pliers or tongs, never with a gloved hand. Wear gloves when cooling metal in water to avoid burns to the hand from the steam that will result.

Harmful Light Rays

Harmful light rays of arc welding can be avoided by the following methods. The workers should wear a welding helmet with at least a No. 10 shaded lens to protect the eyes and face from the intense light when using 200 amps or lower. If 201 - 400 amps is used, a No. 12 lens should be used. A No. 14 lens is required when using in excess of 400 amps. Always check the helmet and lens for cracks before using the equipment. A long-sleeved shirt and gauntlet-style leather gloves are worn to protect the upper body and hands. No skin should be exposed to the internal light. Shout "Cover!" to warn bystanders that you are about to strike an arc. One should never look at the welding arc with the naked eye because painful burns will result and permanent eye damage may occur.

Harmful Fumes

Harmful fumes generated by the burning of metal, flux, and gases should be minimized with proper ventilation. Always work in a well-ventilated area. Keep your head out of the welding fumes. It is not advisable to weld brass, galvanized, or cadmium-plated metals which give off highly toxic fumes. Be cautious when welding brazed materials, since brazing involves brass.

Fire

In order to limit the danger of fire, the worker should avoid welding over a wood floor, but instead weld over concrete floors or fireproof surfaces. Do not weld when wearing clothing that is dirty or oil-soaked. Always clear the work area of flammable materials before welding. Use a dry chemical fire extinguisher to fight fires near the welder. Do not use water to fight electrical fires. Keep the welding area clean. Never weld or heat drums or other containers that have been used for storing gasoline, oil, or other flammable materials.

Suitable Clothing and Footwear

The welder is required to wear proper clothing and footwear to avoid injury. The clothing worn in the shop should be made of natural fiber such as cotton or wool. Avoid wearing clothing made with synthetic fiber such as polyester, acrylic, and nylon. These materials melt when exposed to high heat and can add to the severity of a burn injury.

Shirts should be long-sleeved with the collar and sleeves buttoned to cover any skin. Work pants should be cuffless and have no frayed edges. Dark clothing is better than light clothing when welding since light clothing can reflect light rays under the helmet, which can result in burns to the skin and eyes.

Gloves should be worn to protect the hands and forearms. Welding gloves are generally made of a type of leather and are gauntlet style. High-top leather boots should be worn by the welder to protect the feet from hot metal and falling embers. For the safety of the worker, low shoes, cloth shoes, and tennis shoes of any style should not be worn.

Precautions for Removing Slag

Welding is not the only dangerous activity in working with metal. Once the weld is made, the bead should be cleaned of slag and residue from the gas shields. The weld should be allowed to cool before removing slag. Clear goggles with side shields should be worn when chipping away slag and brushing or grinding the weld. When chipping slag, the hammer should strike the bead near the point where the slag meets the metal. The slag should be chipped away from the worker to avoid burns from the slag and to reduce the chance of getting slag in the eyes.

Medical Attention in Case of Injury

Medical attention is required for injuries in the shop. You should notify the instructor immediately of any injury, regardless of how serious it may seem. The school nurse should be notified when an injury has occurred so that proper medical treatment will be administered. If the injury is not realized until after school, seek medical attention immediately to ensure that proper treatment is received.

Precautions for Cutting Containers

Never cut or weld any container that has been used to store gasoline, oil, or other flammable substances. Contact with the flame produced during these operations may cause an explosion that could injure anyone in the area. Even though the container may look clean inside, fumes may still exist. Welding should not be done on sealed containers unless vents are provided. Cut containers with spark-resistant tools (e.g., cold chisels, saber saw).

UNIT I - ARC WELDING

Lesson 2: Identification of Metals and Their Properties

Objective: The student will be able to identify the various types of metals and their properties.

Study Questions

1. **How are metals classified?**
2. **What metals are commonly used in agricultural construction?**
3. **How are metals identified?**
4. **How can the weldability of a metal be improved?**
5. **What are the welding properties of metals common to agricultural construction?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 2.1: Identification of Metals and Their Properties

UNIT I - ARC WELDING

Lesson 2: Identification of Metals and Their Properties

TEACHING PROCEDURES

A. Review

Review Lesson 4, "How Can I Identify the Metal to Be Welded?" from "Agricultural Mechanics," Agricultural Science II.

NOTE: Students will be introduced to basic metallurgy in this lesson. Metallurgy is the study of the properties, behavior, and internal structure of metals.

B. Motivation

This motivation is potentially dangerous. A proper fire extinguisher should be readily available. Perform the experiment at a safe distance from the students. Rehearse the experiment beforehand.

Obtain small samples of common metals, such as cast iron, aluminum, stainless steel, mild steel, and magnesium. Heat each sample with a torch flame. Compare how the metals react to heat. Since magnesium is flammable, be cautious of its reaction. Discuss the importance of knowing about metals to be welded.

C. Assignment

D. Supervised study

E. Discussion

1. Metals are used in items we see and use daily. Challenge students to name different objects that are made of metal. Distribute HO 2.1.

How are metals classified?

a) Metals are classified by their similarities and differences. A common method of classification deals with the element(s) contained within the metals. Metals may vary in chemical composition. The makeup of the metal influences the need for preheating and postheating of the metal in welding. A metal's chemical composition may vary in the following ways:
   1) Iron content - Ferrous metals contain iron while non-ferrous metals contain very little or no iron.
   2) Carbon content - The higher the percentage of carbon, the harder the metal.
   3) Alloying elements - Alloys are a mixture of two or more metals or a mixture of metal and non-metal.

b) Metals may be classified in the following ways:
   1) Ferrous metals
      (a) Pig iron
      (b) Cast iron
      (c) Wrought iron
      (d) Steel - low-, medium-, and high-carbon steel

2) Nonferrous metals
   (a) Aluminum
   (b) Copper
   (c) Lead
   (d) Magnesium
   (e) Nickel
   (f) Tin
   (g) Tungsten
   (h) Zinc
   (i) Silver
   (j) Gold
3) Ferrous alloy metals
   (a) Manganese steel
   (b) Chrome steel
   (c) Nickel steel
   (d) Stainless steel
   (e) Tungsten steel
   (f) Molybdenum steel
   (g) Vanadium steel
   (h) Silicon steel
   (i) Aluminum steel
   (j) Phosphorous steel
4) Nonferrous alloy metals
   (a) Brass
   (b) Bronze
   (c) Solder
   (d) Pewter
   (e) Monel

2. There are many types of metals. Each metal possesses specific properties and characteristics. Certain metals are used in agriculture because they meet the needs of the users. Encourage students to brainstorm and list properties of metals that may be needed in agriculture and agricultural construction. Select metals listed in Question 1 that are common to agriculture.

What metals are commonly used in agricultural construction?

a) Ferrous metals
   1) Low-carbon steel
   2) Medium-carbon steel
   3) High-carbon steel
   4) Cast iron
   5) Stainless steel (ferrous alloy)
b) Nonferrous metals
   1) Aluminum
   2) Bronze (nonferrous alloy)
   3) Brass (nonferrous alloy)

3. Different metals are used for specific purposes in specific situations. Metals may often be identified by their use. There are a variety of methods used in metal identification. Some students may already be able to identify some metals. Ask these students how they identify a metal.

How are metals identified?

a) Surface appearance
   1) Color
   2) Texture
   3) Casting marks
b) Magnetic test - Ferrous metals are magnetic depending on the percentage of iron contained.
c) Chisel test - Metals have characteristic chips or shavings as they are chiseled or machined.
d) Fracture test
   1) Degree of bending before breaking
   2) Texture of metal's grain within
   3) Color of metal within
e) Heat test
   1) Melting rate and temperature
   2) Color and change of color during heating
f) Spark test
   1) Sparks are observed as the metal stock is uniformly pressed to the grinding wheel.
   2) Recommended grinding wheel speed: minimum of 5,000 surface feet per minute (sfpm)

$$\text{sfpm} = \frac{\text{wheel circumference in inches x RPM}}{12}$$

4. Some metals are easier to work with than others. The properties of a metal determine its weldability. Discuss weldability with students. Weldability is the relative ability of a metal to be welded to obtain proper strength and to perform in its intended service. If a metal has undesirable welding characteristics, corrections can be made by one or a combination of the following ways.

How can the weldability of a metal be improved?

a) Shielding the weld area with gas
b) Changing the filler metal or electrode
c) Changing the fluxing material
d) Changing the welding method
e) Using preheat, postheat, and/or changing the interpass temperature

5. Because metals differ from each other, careful consideration must be made before beginning the welding process. The properties of the metal to be welded should be taken into consideration when determining the welding procedure. Once these properties are analyzed, the proper corrections can be made in order to obtain a high quality weld.

What are the welding properties of metals common to agricultural construction?

a) Low-carbon steel
   1) Easily welded by all welding processes
   2) Extremely high quality welds
   3) Little effect on metal from welding heat
   4) Recommended electrodes - E60XX or E70XX electrode series
b) Medium-carbon steel
   1) Easily welded
   2) Preheating needed to aid the welding process
   3) Low-hydrogen electrodes needed to reduce tendency toward underbead cracking
c) High-carbon steel
   1) Difficult to weld because of the high carbon content
   2) Hard and brittle fusion zone
   3) Preheating and heat treatment after welding needed for best results
   4) Recommended electrodes - E80XX or E90XX electrode series
d) Cast iron
   1) Difficult to weld because of the high carbon content
   2) Preheating and postheating required to prevent cracking
   3) Removal of casting skin required
   4) Recommended electrodes - machinable nickel rod (Eni) or non-machinable (Est)
e) Stainless steel
   1) Stainless steel has a tendency to distort; use a jig for prevention.
   2) Brittleness may be reduced by peening and annealing.
   3) It takes longer to cool (important in prevention of burning holes in metal).
   4) Flux-coated stainless steel electrodes should be used.
f) Wrought iron
   1) Easily welded
   2) Easily shaped
   3) Resistant to corrosion and fatigue
g) Aluminum
   1) Easy to work
   2) Weighs approximately one-third as much as other metals
   3) Strong for its weight
   4) Corrosion resistant
   5) Requires gas shielded arc process (MIG or TIG) for best results
   6) Often mixed with other elements to form a stronger alloy
h) Bronze
   1) Copper-tin alloy
   2) Easily welded
   3) Mechanical properties similar to mild steel
   4) Resistant to corrosion
   5) Good fatigue resistance
i) Brass
   1) Copper-zinc alloy
   2) Good weld quality
   3) Preheating required
   4) Difficult to weld because of oxides formed during the welding process
   5) Good ventilation needed during welding to remove harmful fumes
   6) Subject to tarnishing

F. Other activities

1. Collect various samples of metals and display them as a teaching aid.

2. Assign students specific metals to give a written or oral report.

G. Conclusion

Metallurgy is a complex discipline. It is important to identify the properties of metals and how these properties affect their weldability.

H. Competency

Identify the various types of metals and their properties.

I. Answers to Evaluation

1. a
2. c
3. d
4. b
5. d
6. d
7. c
8. b
9. e

Name _____

Lesson 2: Identification of Metals and Their Properties

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Metals are typically classified by _____.

   a. Content
   b. Weight
   c. Density
   d. Flammability
   e. Color

2. Which of the following metals is a ferrous metal?

   a. Tin
   b. Lead
   c. Steel
   d. Aluminum
   e. Zinc

3. Which of the following metals is a nonferrous metal?

   a. Wrought iron
   b. Stainless steel
   c. Cast iron
   d. Copper
   e. High carbon steel

4. Which of the following metals is an alloy?

   a. Magnesium
   b. Bronze
   c. Pig iron
   d. Lead
   e. Zinc

5. Ferrous metals are magnetic depending on the percentage of _____.

   a. Lead
   b. Aluminum
   c. Copper
   d. Iron
   e. Silicon

6. The metal identification test using a grinding wheel speed of 5,000 surface feet per minute is called the _____.

   a. Magnetic test
   b. Iron test
   c. Grinder test
   d. Spark test
   e. Speed test

7. Bending the metal to determine the degree before it breaks is called the _____.

   a. Spark test
   b. Chisel test
   c. Fracture test
   d. Magnetic test
   e. Heat test

8. Which metal requires a nickel rod (Eni) electrode for welding?

   a. Stainless steel
   b. Cast iron
   c. Aluminum
   d. Bronze
   e. Wrought iron

9. Which of the following metals would most likely require TIG welding for best results?

   a. Low-carbon steel
   b. High-carbon steel
   c. Cast iron
   d. Stainless steel
   e. Aluminum

Everything in the universe is made of elements. There are over 100 different known elements in our world; seventy-five of these are metals. We use metals every day. They exist in our bodies, our food, our homes, at school--they are everywhere!

We use metal for construction because of its availability, strength, and durability. The more you learn about metals, the better you will be able to use them.

Classification of Metals

Metals are classified by their similarities and differences. A common method used to classify metals is determined by the element or elements that make the metal; metals are commonly classified by iron content, carbon content, or alloying elements. Metals also vary in chemical composition.

Ferrous metals contain iron and are susceptible to oxidation (rusting). Nonferrous metals contain very little or no iron.

Many metals contain carbon. The higher the percentage of carbon, the harder the metal. Generally, as the carbon content increases, the metal becomes more difficult to weld. Many metals used in welding are not pure elements, but are composed of a mixture of two or more pure elements, or a mixture of metal and non-metal. These metals are known as alloys.

Metals may be classified in the following ways:

1. Ferrous metals
   a) Pig iron
   b) Cast iron
   c) Wrought iron
   d) Steel - low-, medium-, and high-carbon steel
2. Nonferrous metals
   a) Aluminum
   b) Copper
   c) Lead
   d) Magnesium
   e) Nickel
   f) Tin
   g) Tungsten
   h) Zinc
   i) Silver
   j) Gold
3. Ferrous alloy metals
   a) Manganese steel
   b) Chrome steel
   c) Nickel steel
   d) Stainless steel
   e) Tungsten steel
   f) Molybdenum steel
   g) Vanadium steel
   h) Silicon steel
   i) Aluminum steel
   j) Phosphorous steel

4. Nonferrous alloy metals
    a) Brass
    b) Bronze
    c) Solder
    d) Pewter
    e) Monel

Metals Commonly Used in Agricultural Construction

Certain metals are used in agriculture because they meet the needs of the user or of the job to be performed. Some metals are common to agricultural use while others are rarely used on the farm. The metals that are commonly used in agricultural construction include ferrous metals such as low-, medium-, and high-carbon steels, cast iron, and stainless steel. Nonferrous metals and alloys common to agriculture include aluminum, bronze, and brass.

Identification of Metals

Surface appearance - The surface appearance of metals, or the way the metal looks, can be used to identify the material. Metals vary in color, texture, and casting marks.

Magnetic Test - Metals which contain a certain amount of iron are magnetic, so a magnet can be used to determine ferrous metals.

Chisel Test - Each metal has a distinct molecular makeup. A chisel test is a way to distinguish certain metals because of the characteristic shavings or chips made with a cutting edge either by hand or by machine.

Fracture Test - The fracture or breaking test can be used to identify certain metals. The degree of bending before the metal breaks, the texture of the metal inside, and the color of the metal all help to identify the metal.

Heat Test - Some metals may be identified by a heat test. Excess heat applied to metal can cause the metal to change color. The color change can be an indicator of the type of metal. The rate at which the metal melts can also indicate the type of metal.

Spark Test - The spark test is used by many metal workers to determine the type of metal. Each metal has distinguishing sparks when ground on a grinding wheel. The sparks are observed as the metal stock is uniformly pressed to the wheel. The grinding wheel speed must be at least 5,000 surface feet per minute (sfpm). SFPM = wheel circumference in inches x rpm ÷ 12.

Weldability and Treatment of Metals

Some metals are easier to work with than others. The properties of a metal determine its weldability. If a metal has undesirable welding characteristics, corrections can be made in one or more of the following ways:

1. By shielding the weld area with gas
2. By changing the filler metal or electrode
3. By changing the fluxing material
4. By changing the welding method
5. By preheating and postheating

TABLE 1: IDENTIFYING METALS

Metal	Surface Appearance	Magnetic Test	Chisel Test	Fracture Test	Heat Test	Spark Test
Ferrous Metals:						
Low-carbon steel	dark gray	strongly magnetic	continuous chip; smooth edges; chips easily	bright gray	melts fast; becomes a bright red before melting	gives off a long straight line of white sparks with bursts at the end
Medium-carbon steel	dark gray	strongly magnetic	continuous chip; smooth edges; chips easily	very light gray	melts fast; becomes a bright red before melting	gives off lots of yellow sparks with bursts at the end
High-carbon steel	dark gray	strongly magnetic	hard to chip; can be continuous	very light gray	melts fast; becomes a bright red before melting	gives off white line of sparks with star bursts
Cast iron	dull gray	strongly magnetic	not easily chipped; produces small chip pieces	dark gray; porous	melts slowly; becomes a dull red before melting	gives off red sparks near the grinding wheel that turn yellow toward the end of the stream
Stainless steel	bright silver, smooth	slightly magnetic; non-magnetic if high quality	relatively hard to chip	bright gray; smooth	melts fast; becomes bright red before melting	gives off a stream of yellow sparks that fork at the end
Wrought iron	light gray, smooth surface	strongly magnetic	chips easily; smooth continuous chip	bright gray	melts fast	gives off many yellow sparks at the wheel that fork at the end
Nonferrous Metals:						
Aluminum	silver-white	none	easily chipped; smooth chip often continuous	white	melts fast; becomes shiny when melted	none
Bronze	opaque yellow	none	easily chipped; smooth chip often continuous	red to yellow	melts fast	none
Brass	reddish (5-10% zinc) yellowish (2-36% zinc)	none	easily chipped; smooth chip often continuous	red to yellow	melts fast	none

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TABLE 2.2: CHARACTERISTICS OF SOME COMMON METALS

Metal	Uses	Melting Point, °F	Welding Properties
Ferrous Metals:			
Low-carbon steel	implement frames, tanks, brackets, hoods, shop projects, nails, iron bars and rods, auto bodies, pipes	2700	easily welded by all processes; results in extremely high quality welds; resistant to welding heat; recommended electrodes: E60XX or E70XX series
Medium-carbon steel	axles, shafts, machine bolts, boilers, hammers	2600	easily welded; requires preheating; requires low hydrogen electrodes which reduce the tendency toward underbead cracking
High-carbon steel	screwdrivers, crowbars, axes, springs, razors, plowshares, disk blades	2500	difficult to weld because of the high carbon content; hard and brittle fusion zone; requires preheating and postheating for best results; recommended electrodes: E80XX or E90XX series
Cast iron	large pipes, stoves, machinery, engine blocks, machine castings	2300	difficult to weld due to high carbon content; requires preheating and postheating to prevent cracking; removal of casting skin required; recommended electrodes: machinable nickel (Eni) or non-machinable (Est)
Stainless steel	sinks, sanitary equipment, milk tanks, storage containers	2500-2800	has a tendency to distort (Use a jig to prevent this.); requires peening and annealing to reduce brittleness; takes longer to cool; recommended electrodes: flux-coated stainless steel
Wrought iron	decorative metal work, horseshoes, pipes	2900	easily welded; easily shaped, resistant to corrosion and fatigue
Nonferrous Metals:			
Aluminum	storms doors and windows, cooking utensils, airplanes	1215	easily welded; lightweight yet strong; corrosion-resistant; requires gas shielded arc process (TIG or MIG) for best results; often mixed with alloys to improve strength
Bronze	electrical contacts and plugs, fuse connections; used to join different types of metals	1562-1832	easily welded; mechanical properties similar to mild steel; copper-tin alloy; corrosion and fatigue resistant
Brass	plumbing fixtures	1652-1886	copper-zinc alloy; good weld quality; requires preheating; difficult to weld because of skin formed during the welding process; requires good ventilation during the welding process to remove harmful fumes

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UNIT I - ARC WELDING

Lesson 3: Preparation of Metals for Welding

Objective: The student will be able to prepare metals for welding by cutting, grinding, and/or cleaning.

Study Questions

1. **How are metals generally prepared for welding?**
2. **How are metals cut for welding?**
3. **What equipment may be used to cut and grind metal in preparation for welding?**
4. **What is a portable power grinder and how is it used?**
5. **What precautions need to be followed for safe use of the portable power grinder?**
6. **What are the reasons for cleaning metals to be welded?**
7. **How can metal be cleaned before welding?**
8. **Why are some metals beveled before welding?**
9. **What are the various beveling designs used in preparing metals to be welded?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 3.1: Preparation of Metals for Welding

UNIT I - ARC WELDING

Lesson 3: Preparation of Metals for Welding

TEACHING PROCEDURES

A. Review

Review the previous lesson in identifying various metals and their properties. Emphasize the importance of metal identification and its application in project construction. Review "Tool Sharpening and Reconditioning," "Oxy-acetylene Cutting," and "Power Tools" from Agricultural Science I and II.

B. Motivation

Display to students two sets of metal pieces. One set is not cleaned or ground, while another is correctly ground, cleaned, and cut. Discuss the time needed for proper metal preparation in welding. Discuss required strength, ease of welding, and appearance.

C. Assignment

D. Supervised study

E. Discussion

1. The condition of metal to be welded can range from rusty to new, rough cut to exact cut, not ground to ground. Show students samples of each and discuss how metal can best be prepared for welding.

How are metals generally prepared for welding?

a) Cleaned (physically)
b) Ground
c) Beveled
d) Cut

2. For proper fit and penetration, ask students how the metal needs to be cut accurately.

How are metals cut for welding?

a) To the length desired
b) To the bevel desired
c) To the fit desired

3. There is a variety of equipment available for cutting metal. Have students list tools and equipment useful in performing this operation.

What equipment may be used to cut and grind metal in preparation for welding?

a) Cutting
    1) Abrasive cutoff saw
    2) Power hacksaw

3) Stationary band saw
4) Portable band saw
5) Hand hacksaw
6) Oxyfuel torch
7) Arc cutting electrode and welder
8) Metal shears
9) Compressed air with electric arc
10) Plasma arc
11) Cold chisel
12) Saber saw

b) Grinding
1) Bench grinder
2) Portable power grinder
3) Belt sander

4. The portable power grinder is a common tool in both agricultural and industrial shops. Ask students to list situations where a portable power grinder would best be used.

What is a portable power grinder and how is it used?

a) The portable power grinder is also known as a disc grinder.
b) It is a rotary type machine.
c) It is used for removing paint, grinding, metal and grinding welds.
d) It can be powered electrically or pneumatically (by air).

5. The portable power grinder has potential danger for the user and others in the work area. Ask students to list safety precautions that they feel would be necessary in using such a piece of equipment.

What precautions need to be followed for safe use of the portable power grinder?

a) Follow manufacturer's recommendations.
b) Wear face shield.
c) Wear respirator when grinding certain materials.
d) Disconnect power before making adjustments or changes.
e) Grinder should come to a complete stop before being laid on the floor.
f) Never grind near flammable materials.
g) Check and repair frayed cords and unsafe plugs before using.
h) Be sure grinder is properly grounded.
i) Do not stand on wet floor when grinding.
j) Have good footing and balance when grinding.
k) Hold grinder firmly with both hands.
l) Keep alert at all time.
m) Check grinding wheel for cracks and damage before using.
n) Use only designated wheels and attachments for machine.
o) Tighten wheel securely; do not overtighten because it might crack.
p) Discard wheels that are less than half the original size.
q) Secure small pieces to be ground.
r) Do not direct sparks toward people, clothing, or other combustible materials.
s) Do not lay the machine down on the disc.
t) Keep the guard on at all times.
u) Keep the power cord out of the way of the disc.
v) Do not apply too much pressure to the disc; it could be damaged.

6. Discuss with students what impurities may be present on metals. All rust, scale, paint, or dirt must be removed from metal before welding.

What are the reasons for cleaning metals to be welded?

a) Impurities cause poor fusion or bending of base metals, reducing their strength.
b) Impurities or foreign material are poor conductors of electricity.
c) Impurities or foreign material interfere with control and manipulation of the arc.
d) Weld appearance is improved when impurities are removed.

7. Display to students a few common tools used in cleaning metals. Discuss safe procedure for using each of the tools listed. Have students list other methods and tools.

How can metal be cleaned before welding?

a) Hand wire brush
b) Bench or portable wire wheel
c) Bench or portable grinder
d) Sand blasting unit
e) Torch (to burn off oils)
f) Detergent and water (to remove dirt and oils)
g) Steam cleaned

8. Discuss with students the reasoning behind beveling metal stock.

Why are some metals beveled before welding?

a) Metals exceeding 1/8 inch require beveling for deeper weld penetration.
b) Metals exceeding 3/8 inch require veeing on top and bottom for deeper weld penetration.

9. Bring in samples of various beveling designs. Discuss applications of each.

What are the various beveling designs used in preparing metals to be welded?

a) Single V-joint
b) Double V-joint
c) Single-bevel joint
d) Double-bevel joint
e) Feather edge
f) Shoulder edge

F. Other activities

1. Construct a teaching aid of the various joint designs with beveled edges.

2. Give a demonstration on the safe use of a sandblaster. Show how it can best be used for different jobs in the agricultural shop.

3. Make a maintenance chart for metal cutting equipment in the agricultural shop.

4. Demonstrate safe use of portable power grinder.

G. Conclusion

There is a certain amount of preparation of metals prior to the welding operation. The condition of the metal stipulates the amount of preparation.

H. Competency

Prepare metals for welding by cutting, grinding, and/or cleaning.

I. Answers to Evaluation

1. d
2. b
3. a
4. b
5. d
6. c
7. a
8. d
9. e
10. b

Name _____

Lesson 3: Preparation of Metals for Welding

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following equipment is not used to cut metal in preparation of welding?

   a. Plasma arc
   b. Oxyfuel torch
   c. Portable band saw
   d. Cross cut saw
   e. Abrasive cutoff saw

2. Which of the following tools is used for grinding?

   a. Abrasive cutoff saw
   b. Disc grinder
   c. Oxy-fuel torch
   d. Portable bandsaw
   e. Cold chisel

3. Impurities in metals to be welded may cause _____.

   a. Poor fusion
   b. A poor paint job
   c. An electric shock
   d. High stress
   e. Increased tensile strength

4. Metal should be beveled on one side if thicker than _____.

   a. 1/16"
   b. 1/8"
   c. 1/4"
   d. 3/8"
   e. 1/2"

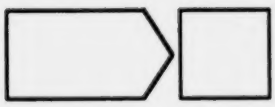
5. Metal requires a veeing on both top and bottom when having a thickness over _____.

   a. 1/8"
   b. 3/16"
   c. 1/4"
   d. 3/8"
   e. 1/2"

Place the letter in the blank that corresponds to the correct illustration.

6. _____ Single bevel joint
7. _____ Double bevel joint
8. _____ Feather edge
9. _____ Double V-joint
10. _____ Single V-joint

a.



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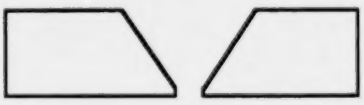

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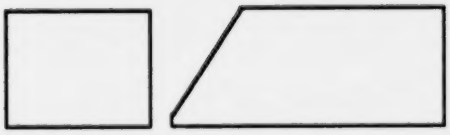
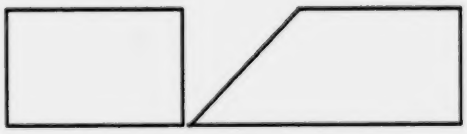


d.



e.

Preparation of Metals for Welding

Metals are generally prepared for welding by cleaning, cutting, grinding, and beveling.

Cutting

Much time and work can be saved if the metal is cut to the desired length, bevel, and fit before fabrication or assembly begins.

Equipment for Cutting and Grinding

A variety of equipment is available for cutting and grinding metal. Each piece of equipment is designed for specific uses or purposes. One piece of equipment might perform better than another under certain circumstances and situations. Your experience in using equipment will be valuable for judging what is best for a job. The following equipment is used for cutting metal:

Abrasive cutoff saw
Power hacksaw
Stationary band saw
Portable band saw
Hand hacksaw
Oxyfuel torch
Arc cutting electrode and welder
Metal shears
Compressed air with electric arc
Plasma arc
Cold chisel
Saber saw

Some tools are available specifically for grinding. They include the bench grinder, portable power grinder, and belt sander. Care must be taken in using any power tool that cuts or grinds. Goggles are required.

The Portable Power Grinder

The portable power grinder (sometimes called the disc grinder) is a common tool used in both agricultural and industrial shops. It is a rotary type machine that is used to remove paint and impurities, and to grind metal. The portable power grinder can be pneumatic (powered by air) or electrical.

Safe Use of the Portable Power Grinder

The portable power grinder is potentially dangerous for the user as well as others in the working area. The following precautions should be used in working with a portable power grinder:

1. Follow manufacturer's recommendations. Read the owner's manual before using.
2. Wear face shield.
3. Wear respirator when grinding certain materials.
4. Disconnect power before making adjustments or changes.
5. Bring grinder to a complete stop before laying it on the floor.
6. Never grind near flammable materials.

7. Check for frayed cords and unsafe plugs and repair before using.
8. Be sure grinder is properly grounded.
9. Do not stand on wet floor when grinding.
10. Maintain good footing and balance when grinding.
11. Hold grinder firmly with both hands.
12. Keep alert at all time.
13. Check grinding wheel for cracks and damage before using.
14. Use only designated wheels and attachments for machine.
15. Tighten wheel securely; do not overtighten, because it might crack.
16. Discard wheels that are less than half the original size.
17. Secure small pieces to be ground.
18. Do not direct sparks toward people, clothing, or other combustible materials.
19. Do not lay the machine down on the disc.
20. Keep the guard on at all times.
21. Keep the power cord out of the way of the disc.
22. To avoid damage to the disc, do not apply excess pressure to the grinder.

A wide range of metals, including new and used materials, are used for agricultural construction. Regardless of the appearance or condition of the metal, it is important to properly prepare it before welding.

Impurities such as paint, rust, grease, dirt, and oil influence weld quality. Impurities cause poor fusion or bending of the base metals, and they are also poor conductors of electricity. Foreign material and impurities in or on metal stock interfere with control and manipulation of the electric arc. The weld appearance is improved when impurities are removed from the metal.

Tools and Methods

The methods used to clean metals prior to welding involve hand and power tools. The hand wire brush, bench or portable wire wheel, bench or portable grinder, sand blasting unit, and torch can all be used to clean, grind, or burn off impurities. A detergent and water solution can be used to remove dirt and oils.

Beveling Metals

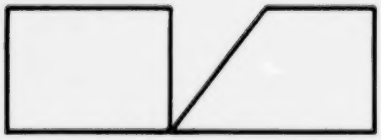
Metals that are over 1/8 inch in thickness require beveling for deep weld penetration. Those metals that exceed 3/8 inch require veeing on top and bottom for deep weld penetration. The following illustrations are samples of various beveling weld designs.

single v-joint

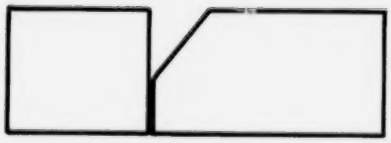
double v-joint

single-bevel joint

double-bevel joint



feather edge



shoulder edge

UNIT I - ARC WELDING

Lesson 4: Shielded Metal Arc Welding

Objective: The student will be able to weld in all positions with the shielded metal arc welder.

References

1. Giachino, J.W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, 1985.

2. Demonstration Sheets

   a) DS 4.1: Welds in the Flat Position
   b) DS 4.2: Welds in the Horizontal Position
   c) DS 4.3: Welds in the Vertical-Up Position
   d) DS 4.4: Welds in the Vertical-Down Position
   e) DS 4.5: Welds in the Overhead Position

3. Job Sheets

   a) JS 4.1: Welds in the Flat Position
   b) JS 4.2: Welds in the Horizontal Position
   c) JS 4.3: Welds in the Vertical-Up Position
   d) JS 4.4: Welds in the Vertical-Down Position
   e) JS 4.5: Welds in the Overhead Position

UNIT I - ARC WELDING

Lesson 4: Shielded Metal Arc Welding

TEACHING PROCEDURES

NOTE: This lesson on shielded metal arc welding covers butt, lap, and T-fillet joints in all positions. The electrodes used in this lesson are different than those used in arc welding exercises of the agricultural mechanics units in Agricultural Science I and II printed by the Instructional Materials Laboratory. To reduce the amount of paper required to teach this lesson, each demonstration sheet and each exercise sheet combines the three types of joints for each position and the three types of electrodes.

A. Review

Review the previous lesson on preparing metals for welding. The arc welding units in the Agricultural Science I and II curriculum (using an E6013 electrode) should also be reviewed. Emphasize the need for proper preparation for optimum fusion and strength of the weld.

B. Motivation

Using an agricultural implement as an example, point out the various welds used to fabricate the unit. Ask students to devise the best and easiest methods to accomplish the welds.

C. Assignment

The demonstration sheets are to be used by the instructor. The job sheets are used by students to develop skill in all-position welding of common joint designs and electrodes. In order to evaluate the student's performance of a competency, each job sheet should be graded independently. Use individual job sheets and competency profile cards to record earned grades and to designate competencies that are mastered. Stress the safety precautions that are to be observed while working in the shop area. Be sure to have documentation of safety instruction on file for each student working in the shop area.

D. Supervised study

Review the job sheets to be completed by each student.

E. Discussion

Discuss with students the before-, during-, and after-welding practices; acceptable techniques; and desired results. Safety practices should be stressed during demonstrations to avoid injury to students while welding.

F. Other activities

1. Construct a bin with several compartments for storing students' welding coupons.

2. Collect and exhibit a range of welds from high- to medium- to low-quality. Use them as a teaching aid for students.

G. Conclusion

Welding is an important skill to individuals involved in agribusiness and other sectors of industry. It is used in construction and repair of structures, implements, and parts. Mastery of the ability to weld in all positions takes both time and practice.

H. Competency

Weld in all positions with the stick welder (shielded metal arc welder).

a. Weld in flat position using 6010 & 7018
b. Weld in horizontal positions using 6010, 6011, & 7018
c. Weld in vertical up position using 6010, 6011, & 7018
d. Weld in vertical down position using 6010 & 6011
e. Weld in overhead position using 6010, 6011, & 7018

I. Evaluation

Mastery of the competency is based on the student's performance on the exercises in the job sheets for this unit.

Demonstration Sheet 4.1: Welds in the Flat Position

Objective: At the completion of this demonstration, the student will be ready to weld a butt joint, a lap joint, and a T-fillet joint in the flat position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC or AC/DC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used.

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. Metals less than 1/8" in thickness may be welded without beveling the edges. If a space is left between the metal, a backup strip should be used to prevent burnthrough on the bottom side of the metal.

4. Metals greater than 1/8" in thickness should be beveled into a V-groove to allow for better penetration. Metals exceeding 3/8" should be beveled on both sides.

5. Remove dirt, grease, and foreign materials from the surface of the metal.

6. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

7. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded will be in a flat position.
2. The electrode should be held at a 90 degree work angle and a 25 to 30 degree travel angle.
3. Lower the helmet. Strike the arc and adjust to a medium arc length.
4. Deposit a bead across the entire length of the joint. If welding thin metal, move along the joint without using a weaving motion. Thicker metal requires the use of a weave motion.
5. Reposition the metal and deposit a bead on the opposite side of the joint.
6. With safety goggles on, chip the slag from the weld and clean with a wire brush.
7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

LAP JOINT

1. Position the plates so that the joint to be welded is in the flat position.
2. The electrode should be used with a 45 degree work angle and a 25 to 30 degree travel angle.
3. Lower the helmet. Strike the arc and adjust to a medium length.
4. Deposit the weld across the entire length of the joint. If the metal exceeds 3/8" in thickness, additional passes may be needed to fill the joint and provide the strength needed.
5. Turn the metal over and deposit a bead on the back side of the joint.
6. With safety goggles on, chip the slag from the weld and clean with a wire brush.
7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

T-FILLET JOINT

1. Position the plates so that the joint to be welded will be in the flat position.
2. The electrode should be held at a 45 degree work angle and a 30 degree travel angle.
3. Lower the helmet. Strike the arc and adjust to a medium length.
4. Deposit the weld across the entire length of the joint. When making a single pass fillet weld, no weave pattern should be used.
5. Reposition the metal and deposit a bead on the opposite side of the joint.

6. With goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean the slag chippings from the table and floor.

Demonstration Sheet 4.2: Welds in the Horizontal Position

Objective: At the completion of this demonstration, the student will be ready to weld a butt joint and a T-fillet joint in the horizontal position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC or AC/DC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Preweldlng Procedure:

1. Select the correct polarity for the electrode being used.

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. One edge of the joint should be beveled when making a butt joint in the horizontal position to establish a shelf for help in controlling the weld puddle.

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

6. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates in a vertical position so that the joint to be welded will be on a horizontal plane.

2. The electrode should be used with a 5 - 10 degree work angle and a 20 degree travel angle.

3. Lower the helmet. Strike the arc and adjust to a short arc length. This will help prevent the weld puddle from sagging.

4. Deposit the weld along the entire length of the joint, using a slight weaving motion.

5. Reposition the metal and lay a bead on the opposite side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

T-FILLET JOINT

1. Position the metal plates so that the joint to be welded will be in a horizontal position.

2. The electrode should be used with a 45 degree work angle and a 20 to 30 degree travel angle.

3. Lower the helmet. Strike the arc and adjust to a medium arc length.

4. Deposit the weld along the entire length of the joint, using a slight weaving motion.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean the slag chippings from the table and floor.

Demonstration Sheet 4.3: Welds in the Vertical-Up Position

Objective: At the completion of this demonstration, the student will be ready to weld a butt joint, a lap joint, and a T-fillet joint in the vertical-up position using E6010, E6011, and E7018 electrodes.

Tools Needed:

1. AC/DC or AC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 electrode
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used:

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. Bevel both edges of the joint to a 60 degree angle.

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

6. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded is in the vertical position. Lower the welding helmet.

2. As you begin the weld, the tip of the electrode should be at a 90 degree angle to the bottom of the joint. Keep a short arc that will allow more control of the weld puddle.

3. As you begin the weld, tilt the electrode 10 to 15 degrees away from the direction of travel. Use a whipping motion to produce a fairly narrow bead.

   NOTE: The speed of welding should be slightly faster than for a butt weld in the flat position. Moving too quickly will result in an uneven bead with poor penetration. Moving too slowly will result in a large weld puddle that will be hard to control and will have a tendency to sag.

4. Reposition the metal and deposit a bead on the opposite side of the joint.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

LAP JOINT

1. Position the plates so that the lap joint to be welded will be in the vertical position.

2. The electrode should be positioned at a 45 degree work angle and a 10 to 20 degree travel angle.

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. Deposit the weld along the entire length of the joint.

   NOTE: If the metal exceeds 3/8 inches in thickness, additional passes may be needed to fill the joint and improve the strength of the joint.

5. Reposition the metal and deposit a bead on the opposite of side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

T-FILLET JOINT

1. Position the plates so that the joint to be welded will be in a vertical position.

2. The electrode should be positioned at a 90 degree travel angle and a 45 degree work angle at the bottom of the joint.

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. As you move up the joint, the electrode should be changed to a 10 to 20 degree travel angle, while maintaining the 45 degree work angle. A whipping motion should be used to produce the desired bead.

5. Deposit the weld along the entire length of the joint.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without the proper protection.

5. Clean the slag chippings from the table and floor.

Demonstration Sheet 4.4: Welds in the Vertical-Down Position

Objective: At the completion of this demonstration, the student will be ready to weld a butt joint, a lap joint, and a T-fillet joint in the vertical-down position using E6010, E6011, and E7018 electrodes.

Tools Needed:

1. AC/DC or AC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 electrode
2. Mild steel plates - size to be determined by the instructor

Preweldlng Procedure:

1. Select the correct polarity for the electrode being used:

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. With safety goggles on, bevel both edges of the joint to a 60 degree angle.

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded is in the vertical position. Lower the welding helmet.

2. As you begin the weld, the tip of the electrode should be at a 90 degree work angle to the top of the joint. Keep a short arc that will allow more control of the weld puddle.

3. As you begin the weld, tilt the electrode 15 to 30 degrees toward the direction of travel. Use a slight whipping motion to produce a fairly narrow bead.

   NOTE: The speed of welding should be fast enough to prevent the molten metal from falling ahead of the crater. Moving too quickly will result in an uneven bead with poor penetration. Moving too slowly will result in a large weld puddle that will be hard to control and will have a tendency to sag.

4. Reposition the metal and deposit a bead on the opposite side of the joint.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

LAP JOINT

1. Position the plates so that the lap joint to be welded will be in the vertical position.

2. The electrode should be positioned at a 45 degree work angle and a 15 to 30 degree travel angle.

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. Deposit the weld along the entire length of the joint.

5. Reposition the metal and deposit a bead on the opposite of side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

T-FILLET JOINT

1. Position the plates so that the joint to be welded will be in the vertical position.

2. The electrode should be positioned at a 90 degree travel angle and a 45 degree work angle at the top of the joint.

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. As you move up the joint, the electrode should be changed to a 15 to 30 degree travel angle, while maintaining the 45 degree work angle. A slight whipping motion should be used to produce the desired bead.

5. Deposit the weld along the entire length of the joint.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without the proper protection.

5. Clean the slag chippings from the table and floor.

Demonstration Sheet 4.5: Welds in the Overhead Position

Objective: At the completion of this demonstration, the student will be ready to weld a butt joint and T-fillet joint in the overhead position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC/DC or AC Welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*
8. Weld positioner

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used.

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. Remove dirt, grease, and foreign materials from the surface of the metal.

4. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

5. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the metal plates so that the joint to be welded will be in an overhead position.

2. Position the electrode in the electrode holder so that you may weld in the most comfortable position. There are several electrode positions that may be used for overhead welding.

3. The electrode should be held at a 90 degree work angle and a 10 to 15 degree travel angle.

4. Lower the helmet to strike the arc and maintain a fairly long arc until the puddle begins to form. Once the puddle has formed, a short arc should be maintained to assist in controlling the puddle.

   NOTE: Watch for falling sparks and molten metal from the weld puddle. Stand to one side, rather than directly under the weld. Wear appropriate clothing to avoid injury.

5. Deposit the weld along the entire length of the joint, using a slight whipping motion.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld for penetration and bead appearance. Discuss possible improvements with students.

T-FILLET JOINT

1. Position the metal so that the joint to be welded will be in the overhead position.

2. Position the electrode so that you may weld in a comfortable position.

3. The electrode should be held at a 45 degree work angle and a 15 degree travel angle.

4. Lower the helmet. Strike the arc, holding a long arc until the puddle begins to form. Once the puddle forms, maintain a short arc to complete the weld.

5. Deposit the weld along the entire length of the joint, remembering to stand to one side to avoid falling sparks and molten metal.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld for penetration and bead appearance. Discuss possible improvements with the students.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without the proper protection.

5. Clean the slag and chippings from the floor and table of the work area.

Job Sheet 4.1: Welds in the Flat Position

Objective: At the completion of this job sheet, the student will be able to perform a butt joint, a lap joint, and a T-fillet joint in the flat position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC or AC/DC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students performing this procedure must wear the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used.
   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes
2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.
3. Wear safety goggles. Metals less than 1/8" thick may be welded without beveling the edges. A space between the plates of metal to increase penetration may or may not be used. If a space is left between the metal, a backup strip should be used to prevent burnthrough on the bottom side of the metal. (See Figure 4.1.)

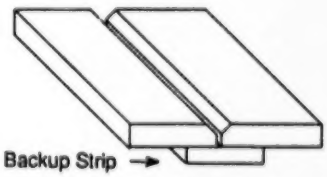


Figure 4.1

4. Wear safety goggles. Metals greater than 1/8" thick should be beveled into a V-groove to allow for better penetration. Metals exceeding 3/8" should be beveled on both sides. (See Figure 4.2.)

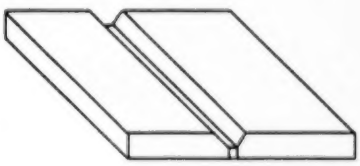


Figure 4.2

5. Remove dirt, grease, and foreign materials from the surface of the metal.

6. Lower the welding helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded will be in a flat position.

2. The electrode should be held at a 90 degree work angle and a 25 to 30 degree travel angle. (See Figure 4.3.)

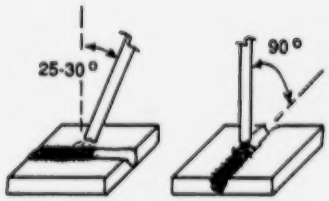


Figure 4.3

3. Lower the helmet. Strike the arc and adjust to a medium arc length.

4. Deposit a bead across the entire length of the joint.

   a. If welding thin metal, move along the joint without using a weaving motion.

   b. Thicker metal requires the use of a weave motion and may require more than one bead to complete the joint. If multiple beads are required, the first bead should be cleaned of slag and allowed to cool before the following bead is deposited.

5. Reposition the metal and deposit a bead on the opposite side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld and turn it in to the instructor for grading.

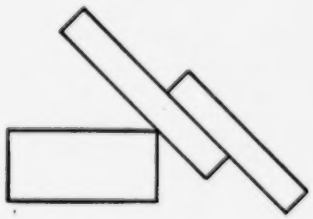


Figure 4.4

LAP JOINT

1. Position the plates so that the joint to be welded is in the flat position. (See Figure 4.4.)

2. The electrode should be used with a 45 degree work angle and a 25 to 30 degree travel angle. (See Figure 4.5.)

3. Lower the helmet. Strike the arc and adjust to a medium length.

4. Deposit the weld across the entire length of the joint. If the metal exceeds 3/8" in thickness, additional passes may be needed to fill the joint and provide additional strength.

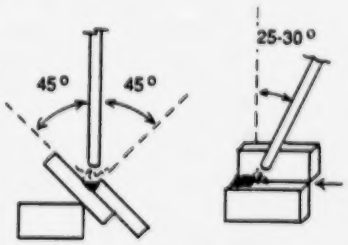


Figure 4.5

5. Turn the metal over and deposit a bead on the back side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld and turn it in to the instructor for grading.

T-FILLET JOINT

1. Position the plates so that the joint to be welded will be in the flat position. (See Figure 4.6.)

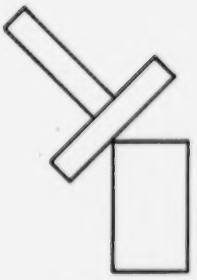


Figure 4.6

2. The electrode should be held at a 45 degree work angle and a 30 degree travel angle. (See Figure 4.7.)

3. Lower the helmet. Strike the arc and adjust to a medium length.

4. Deposit the weld across the entire length of the joint. When making a single pass fillet weld, no weave pattern should be used.

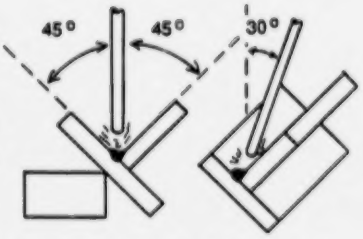


Figure 4.7

5. Reposition the metal and deposit a bead on the opposite side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld and turn it in to the instructor for grading.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the table and floor and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean the slag chippings from the table and floor.

Job Sheet 4.2: Welds in the Horizontal Position

Objective: At the completion of this job sheet, the student will be able to perform a butt joint and a T-fillet joint in the horizontal position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC or AC/DC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students performing this procedure must wear the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used:

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. Wear safety goggles. One edge of the joint should be beveled when making a butt joint in the horizontal position to establish a shelf to help control the weld puddle. (See Figure 4.1.)

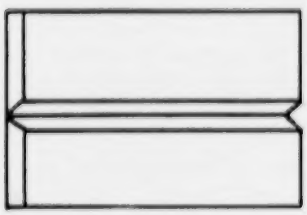


Figure 4.1

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the helmet. Tack weld the plates together to form the proper joint for the weld.

6. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates in a vertical position so that the joint to be welded will be on a horizontal plane. (See Figure 4.2.)

2. Hold the electrode at a 5 to 10 degree work angle and a 20 degree travel angle. (See Figure 4.3.)

3. Lower the helmet. Strike the arc and adjust to a short arc length. This will help prevent the weld puddle from sagging.

4. Deposit the weld along the entire length of the joint, using a slight weaving motion.

5. Reposition the metal and lay a bead on the opposite side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld and turn it in to the instructor for grading.

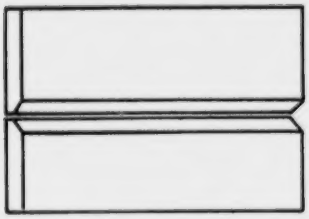


Figure 4.2

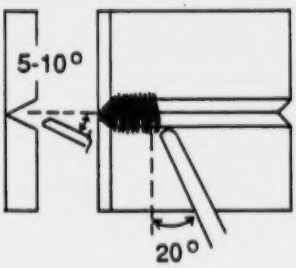


Figure 4.3

T-FILLET JOINT

1. Position the metal plates so that the joint to be welded will be in a horizontal position. (See Figure 4.4.)

2. Hold the electrode at a 45 degree work angle and a 20 to 30 degree travel angle. (See Figure 4.5.)

3. Lower the helmet. Strike the arc and adjust to a medium arc length.

4. Deposit the weld along the entire length of the joint, using a slight weaving motion.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld and turn it in to the instructor for grading.

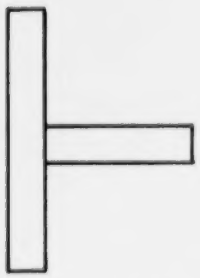


Figure 4.4

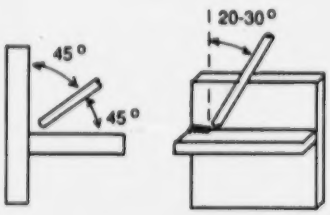


Figure 4.5

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean slag chippings from the table and floor.

Job Sheet 4.3: Welds in the Vertical-Up Position

Objective: At the completion of this job sheet, the student will be able to perform a butt joint, a lap joint, and a T-fillet joint in the vertical-up position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC/DC or AC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students performing this procedure must wear the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 electrode
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used:

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. With safety goggles on, bevel both edges of the joint to a 60 degree angle.

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

6. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Figure 4.1

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded is in the vertical position. (See Figure 4.1.) Lower the welding helmet.

2. Lower the helmet. As you begin the weld, the tip of the electrode should be at a 90 degree angle to the bottom of the joint. Keeping a short arc will help control the weld puddle. (See Figure 4.2.)

3. As you begin the weld, tilt the electrode 10 to 15 degrees away from the direction of travel. (See Figure 4.3.) Use a whipping motion to produce a fairly narrow bead. (See Figure 4.4.)

   NOTE: The speed of welding should be slightly faster than for a butt weld in the flat position. Moving too quickly will result in an uneven bead with poor penetration. Moving too slowly will result in a large weld puddle that will be hard to control and will have a tendency to sag.

4. Reposition the metal and deposit a bead on the opposite side of the joint.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld and turn it in to the instructor for grading.

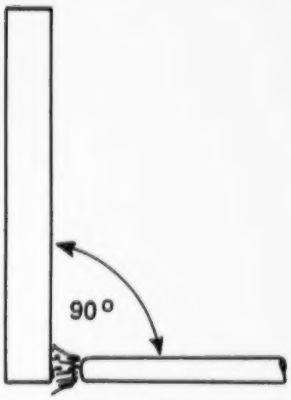


Figure 4.2

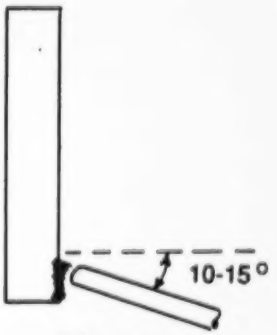


Figure 4.3

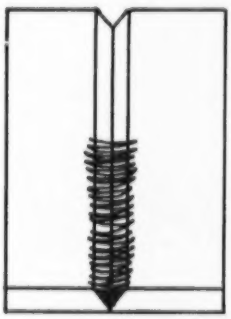


Figure 4.4

LAP JOINT

1. Position the plates so that the lap joint to be welded is in the vertical position. (See Figure 4.5.)

2. Hold the electrode at a 45 degree work angle and a 10 to 20 degree travel angle. (See Figure 4.6.)

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. Deposit the weld along the entire length of the joint.

   NOTE: If the metal exceeds 3/8 inch in thickness, additional passes may be needed to fill the joint and improve the strength of the joint.

5. Reposition the metal and deposit a bead on the opposite of side of the joint.

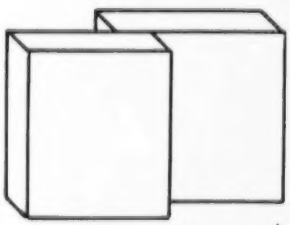


Figure 4.5

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

7. Examine the weld and turn it in to the instructor for grading.

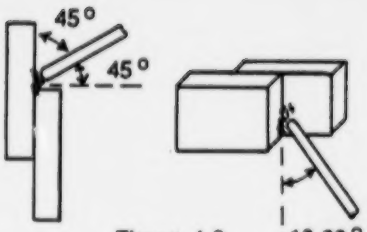


Figure 4.6

T-FILLET JOINT

1. Position the plates so that the joint to be welded is in a vertical position. (See Figure 4.7.)

2. Hold the electrode at a 90 degree travel angle and a 45 degree work angle at the bottom of the joint. (See Figure 4.8.)

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. As you move up the joint, the electrode should be changed to a 10 to 20 degree travel angle, while maintaining the 45 degree work angle. A whipping motion should be used to produce the desired bead. (See Figure 4.9.)

5. Deposit the weld along the entire length of the joint.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld and turn it in to the instructor for grading.

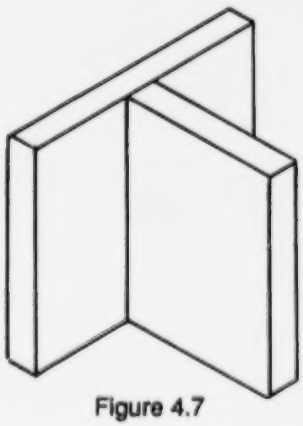


Figure 4.7

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean slag chippings from the table and floor.

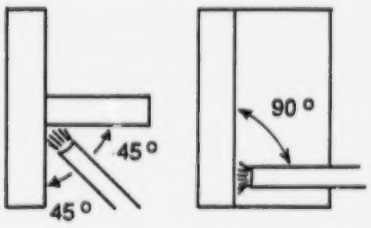


Figure 4.8

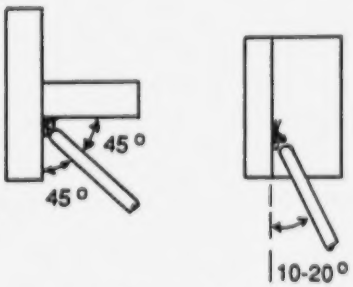


Figure 4.9

Job Sheet 4.4: Welds in the Vertical-Down Position

Objective: At the completion of this job sheet, the student will be able to perform a butt joint, a lap joint, and a T-fillet joint in the vertical-down position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC/DC or AC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*

*CAUTION: All students performing this procedure must wear the proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 electrode
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used:

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. With safety goggles on, bevel both edges of the joint to a 60 degree angle.

4. Remove dirt, grease, and foreign materials from the surface of the metal.

5. Lower the helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

Welding Procedure:

BUTT JOINT

1. Position the plates so that the joint to be welded is in the vertical position. (See Figure 4.1.) Lower the welding helmet.

2. Lower the helmet. As you begin the weld, the tip of the electrode should be at a 90 degree work angle to the top of the joint. Keeping a short arc will help control the weld puddle. (See Figure 4.2.)

3. As you begin the weld, tilt the electrode 15 to 30 degrees toward the direction of travel. (See Figure 4.3.) Use a slight whipping motion to produce a fairly narrow bead. (See Figure 4.4.)

   NOTE: The speed of welding should be fast enough to prevent the molten metal from falling ahead of the crater. Moving too quickly will result in an uneven bead with poor penetration. Moving too slowly will result in a large weld puddle that will be hard to control and will have a tendency to sag.

4. Reposition the metal and deposit a bead on the opposite side of the joint.

5. With safety goggles on, chip the slag from the weld and clean with a wire brush.

6. Examine the weld and turn it in to the instructor for grading.

LAP JOINT

1. Position the plates so that the lap joint to be welded is in the vertical position. (See Figure 4.5.)

2. Hold the electrode at a 45 degree work angle and a 15 to 30 degree travel angle. (See Figure 4.6.)

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. Deposit the weld along the entire length of the joint.

5. Reposition the metal and deposit a bead on the opposite of side of the joint.

6. With safety goggles on, chip the slag from the weld and clean with a wire brush.

Figure 4.1

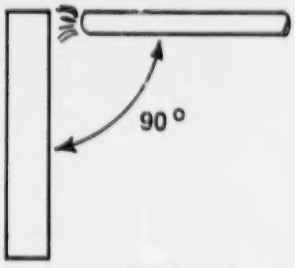


Figure 4.2

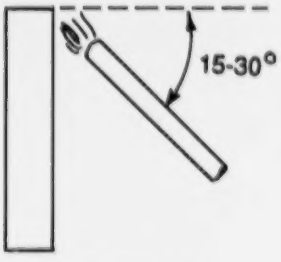


Figure 4.3

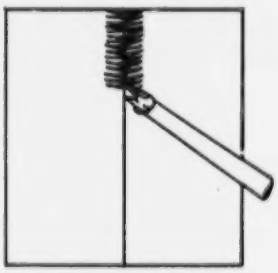


Figure 4.4

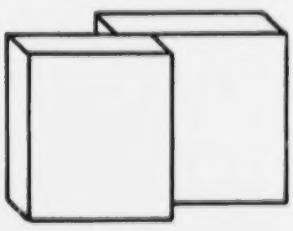


Figure 4.5

7. Examine the weld and turn it in to the instructor for grading.

T-FILLET JOINT

1. Position the plates so that the joint to be welded is in a vertical position. (See Figure 4.7.)

2. Hold the electrode at a 90 degree travel angle and a 45 degree work angle at the top of the joint. (See Figure 4.8.)

3. Lower the helmet. Strike the arc and adjust to a short arc length.

4. As you move up the joint, the electrode should be changed to a 15 to 30 degree travel angle, while maintaining the 45 degree work angle. A slight whipping motion should be used to produce the desired bead. (See Figure 4.9.)

5. Deposit the weld along the entire length of the joint.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld and turn it in to the instructor for grading.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean slag chippings from the table and floor.

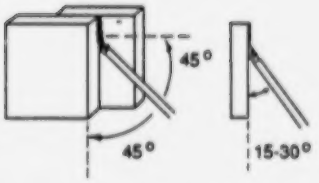


Figure 4.6

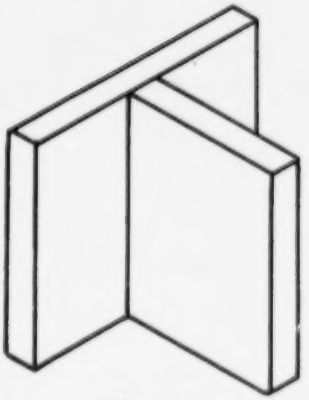


Figure 4.7

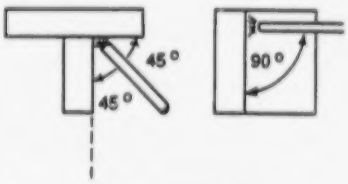


Figure 4.8

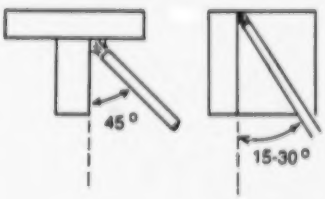


Figure 4.9

Job Sheet 4.5: Welds in the Overhead Position

Objective: At the completion of this job sheet, the student will be able to perform a butt joint and a T-fillet joint in the overhead position using E6010, E6011, and E7018 electrodes.

Tools and Equipment Needed:

1. AC/DC or AC welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Chipping hammer
6. Wire brush
7. Helmet*
8. Weld positioner

*CAUTION: All students performing this demonstration must wear the proper eye protection. Safety precautions should be observed while in the shop area.

Materials Needed:

1. E6010, E6011, and E7018 electrodes - 1/8 inch
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Select the correct polarity for the electrode being used.

   a. DC Reverse Polarity for E6010 electrodes
   b. AC or DC Reverse Polarity for E6011 and E7018 electrodes

2. Initial amperage setting should be 80 to 120 for E6010 and E6011 electrodes and 100 to 150 for E7018 electrodes, depending on the thickness of the metal and the position used.

3. Remove dirt, grease, and foreign materials from the surface of the metal.

4. Lower the helmet. Tack weld the plates together to form the proper joint for the weld to be performed.

5. With safety goggles on, chip the slag from the welds and clean with a wire brush.

Welding Procedure:

BUTT JOINT

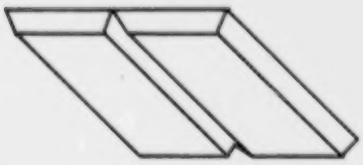


Figure 4.1

1. Position the metal plates so that the joint to be welded is in an overhead position. (Figure 4.1.)

2. Position the electrode in the electrode holder so that you may weld in the most comfortable position. There are several electrode positions that may be used for overhead welding. (See Figure 4.2.)

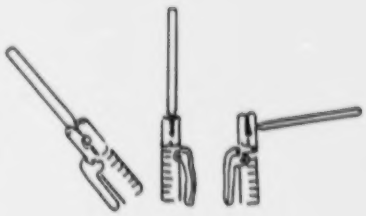


Figure 4.2

3. Hold the electrode at a 90 degree work angle and a 10 to 15 degree travel angle. (See Figure 4.3.)

4. Lower the helmet. Strike the arc and maintain a fairly long arc until the puddle begins to form. Once the puddle has formed, a short arc should be maintained to help control it.

   NOTE: Be cautious of falling sparks and molten metal from the weld puddle. Stand to one side, rather than directly under the weld. Wear appropriate clothing to avoid injury.

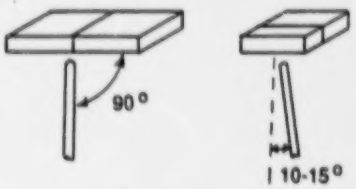


Figure 4.3

5. Deposit the weld along the entire length of the joint, using a slight whipping motion.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld and turn it in to the instructor for grading.

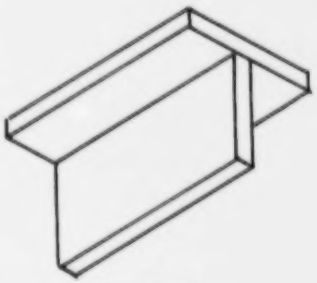


Figure 4.4

T-FILLET WELD

1. Position the metal so that the joint to be welded is in the overhead position. (See Figure 4.4.)

2. Position the electrode so that you may weld in a comfortable position. Refer to Figure 4.2 for possible electrode positions.

3. Hold the electrode at a 45 degree work angle and a 15 degree travel angle. (See Figure 4.5.)

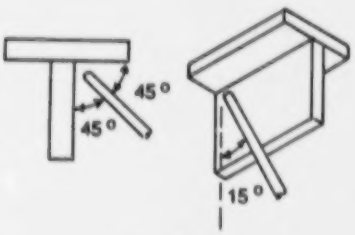


Figure 4.5

4. Lower the helmet. Strike the arc, holding a long arc until the puddle begins to form. Once the puddle forms, maintain a short arc to complete the weld.

5. Deposit the weld along the entire length of the joint, remembering to stand to one side to avoid falling sparks and molten metal.

6. Reposition the metal and deposit a bead on the opposite side of the joint.

7. With safety goggles on, chip the slag from the weld and clean with a wire brush.

8. Examine the weld and turn it in to the instructor for grading.

Postwelding Procedure:

1. When welding for the day is completed, roll the cords up and return them to their proper position.

2. Return all tools to their original location.

3. Remove scrap metal and electrode stubs from the floor and table and clean the work area.

4. Use a piece of soapstone to mark all pieces of metal that may be hot. The word "HOT" should be written in clear view to prevent another person from picking up the metal without proper protection.

5. Clean slag chippings from the table and floor.

UNIT I - ARC WELDING

Lesson 5: Gas Metal Arc Welding (GMAW) MIG*

Objective: The student will be able to gas metal arc weld in all positions.

Study Questions

1. What other names are commonly used for GMAW?
2. What safety precautions need to be followed for GMAW?
3. What are the principles of GMAW?
4. What are the advantages and limitations of GMAW?
5. What are the steps for GMAW setup?
6. What are the steps for GMAW shutdown?

References

1. Giachino, J.W.; W. Weeks. Welding Skills. Alsip, NY: American Technical Publishers, 1985.
2. Demonstration Sheets
   a) DS 5.1: Preweiding and Postwelding Procedures for GMAW
   b) DS 5.2: Welds in the Flat Position
   c) DS 5.3: Welds in the Horizontal Position
   d) DS 5.4: Welds in the Vertical Position
   e) DS 5.5: Welds in the Overhead Position
3. Job Sheets
   a) JS 5.1: Preweiding and Postwelding Procedures for GMAW
   b) JS 5.2: Welds in the Flat Position
   c) JS 5.3: Welds in the Horizontal Position
   d) JS 5.4: Welds in the Vertical Position
   e) JS 5.5: Welds in the Overhead Position

*MIG (Metal Inert Gas) welding is a common name used for gas metal arc welding although some gases used in gas metal arc welding are not inert.

UNIT I - ARC WELDING

Lesson 5: Gas Metal Arc Welding (GMAW) MIG

TEACHING PROCEDURES

A. Review

Review the previous lesson on shielded metal arc welding. Emphasize its application for agricultural use.

B. Motivation

Demonstrate GMAW process and discuss how it can be applied for agricultural use. Show students farm equipment that has been welded with the GMAW process. Have students compare GMAW to stick welds (shield metal arc welding).

C. Assignment

Upon completion of the written evaluation, students should be ready to complete job sheets 5.1 through 5.5.

D. Supervised study

E. Discussion

1. Gas metal arc welding (GMAW) is known in the industry by a number of common names. Educate the students on common names for gas metal arc welding.

   What other names are commonly used for GMAW?

   a) Metal inert gas (MIG) - MIG is a common term for GMAW although some gases used in GMAW are not inert.
   b) Micro-wire welding (Hobart)
   c) Aircomatic welding (Airco)
   d) Sigma welding (Linde)
   e) Millermatic welding (Miller)

2. Show students a GMAW machine. How does the GMAW machine compare to the shielded metal arc welder, or stick welder? Ask students how safety precautions for GMAW are similar and dissimilar to those for shielded metal arc welding.

   What safety precautions need to be followed for GMAW?

   a) Electrical safety
      1) Welder must have an earth ground.
      2) All electrical connections must be tight, clean, and dry.
      3) Keep work area, equipment, and clothing dry.
      4) Never dip a gun in water to cool it.
      5) In multiple-machine operations do not touch hot parts of gun because open-circuit voltages are increased and can cause severe shock.
      6) Disconnect and lock all electric power sources before performing work on any electrical equipment.

7) Keep welding cables close to work.
8) Do not connect cables to building framework.
9) When working in high places, check area for electrical hazards because a shock could cause a fall.

b) Safety with cables and gas and coolant hoses
1) Never drag cables or hoses.
2) Never pull on cable to force it over an obstruction.
3) Use only clean rags to clean cables and hoses. Never use gas or oily rags to clean cables or hoses.
4) Keep cables and hoses free of kinks at all times.
5) Do not drape welding cables over any type of gas cylinder.
6) Never strike an arc on a gas cylinder.
7) Handle shielded gas cylinders with great caution.

c) Safety with electrode wire
1) Always wear safety glasses when handling wire.
2) Position coils close to reel before lifting and lift coil with legs, not back.
3) Never look into a gun while feeding wire through it.
4) Never point the gun at anyone.
5) Never place a finger over a contact tip to determine if wire is feeding.

d) Personal safety equipment
1) Wear welding hood or helmet with shaded lens to protect head from flying sparks and eyes from ultraviolet and infrared radiation.
2) Wear gloves, long sleeved shirt, long pants without cuffs, and work boots to avoid radiation and hot metal burns.
3) Work stations and work areas should be shielded to prevent an arc flash injury of nearby workers or visitors.
4) Lens shade requirements are based on wire size, amperage range, and base metal properties.
5) Select lens shade according to lens manufacturer's selection card. Never select less than a No. 11 lens shade for GMAW.
6) Wear a leather jacket and apron for additional protection.
7) Clothing should be dark and made of cotton or wool. Avoid synthetic clothing. No flammable materials should be carried in the pockets of clothing.

e) Environment safety
1) Every work station should be equipped with a ventilation or exhaust system capable of safely removing dangerous fumes and vapors.
2) Respirators should be worn by welders when welding in confined areas. The respirator should be the air-supplied type or a self-contained breathing apparatus.
3) Argon is heavier than air and will quickly displace oxygen. Precautions should be heeded, especially in confined areas.
4) Ear plugs or earmuffs should be worn in areas subject to high noise levels, especially those levels that are continuous.
5) Lighting should be bright enough to provide good visibility free of glare. Poorly lit areas contribute to eye fatigue, irritation, and poor work.

3. GMAW differs from shielded metal arc welding. How does GMAW work?

What are the principles of GMAW?

a) An electric arc between a continuously fed metal electrode (wire) and the base metal produces heat.
b) The electric arc is shielded by gas.

c) A shielded gas cylinder, regulator, flow meter, and hose provide a flow of shielding gas to the arc.

Note: Industry is beginning to replace the flowmeter with gauges similar to those used in oxy-fuel welding.

d) Shielded gases such as carbon dioxide, argon, or helium may be used.
e) An electrode-feeding device supplies electrodes continuously.
f) A torch and cable carry wire, electricity, and gas to the arc.
g) The torch or gun has a trigger switch for controlling the electrode feed and gas flow.
h) A constant voltage machine is usually used. Direct current Reverse Polarity (DCRP) is recommended.
i) Desired voltage is set on the welding machine.
j) Electric current (amperage) is changed by adjusting the wire feed speed in a constant voltage system. If a constant current system is used, the amperage is adjusted through the voltage setting.
k) Wire speed controls are typically mounted in the wire feed mechanism.
l) Gas volume is adjusted at the gas flow meter or the regulator gauge.
m) The welder should go through the following procedures:
    1) Select electrode size
    2) Set desired voltage
    3) Adjust gas flow
    4) Adjust rate of electrode feed
    5) Control gun movement
    6) Control electrode extension

4. GMAW is useful for a number of jobs. Ask students to consider the advantages and limitations of the GMAW process. List them on the board and discuss them.

What are the advantages and limitations of GMAW?

a) Advantages
    1) Beginners are more quickly trained for GMAW than other welding processes.
    2) Better heat control at weld zone reduces distortion of base metals.
    3) The arc is always visible to the operator since there is less smoke.
    4) A high electrode wire deposition efficiency of 98 percent is typical.
    5) The process is adaptable to both ferrous and nonferrous metals in all thicknesses.
    6) The process is adaptable to either automatic or semi-automatic operations.
    7) Very little cleanup is necessary since little slag is formed.
    8) It can be used easily in all positions.
    9) Faster travel speeds and higher deposition rates can be obtained over tungsten inert gas (TIG) and stick welding.
b) Limitations
    1) It will not function well in the wind.
    2) Careful setting of electrical components is required.
    3) The welding gun must be close to the work; therefore, it is less adaptable to welding in difficult to reach areas than stick welding.
    4) The process is expensive unless used extensively.
    5) Do not use GMAW in welding critical welds and stress points such as hitches, spindles, and shackles, because of the tendency of cold lap to develop.

5. It is necessary to know how to start and shut down GMAW equipment. Ask students why proper setup is necessary. What problems may result with missed steps?

What are the steps for GMAW setup?

a) Check the power cable connections for reverse polarity.
b) Connect gun to the medium slope welding terminal.
c) Connect ground cable to the negative terminal.
d) Connect ground clamp to either work or work table.
e) Start power source: welding machine.
f) Switch wire feeder to the "on" position.
g) Set the wire feed speed control on zero.
h) Check gas shielding supply system.
i) Open gas cylinder outlet valve.
j) Open flow meter valve slowly and squeeze the gun trigger simultaneously.
k) Adjust the gas flow rate as desired. See instructions for specific machine and release the gun trigger.
l) Set wire feed speed to intermediate setting. Wire speed determines welding current in constant voltage systems.
m) Control the electrode stick-out distance appropriately for each process.
n) Adjust welding current as desired.
o) To stop welding, release the gun trigger and withdraw from the work.

6. The shutdown procedure is important for the user's safety and life of the equipment. Students have been introduced to the setup procedure for GMAW; ask them what steps should be included in shutdown. Use DS 5.1 and JS 5.1

What are the steps for GMAW shutdown?

a) Close gas outlet valve at the top of the gas cylinder.
b) Close gun trigger with wire feed speed control on zero to bleed gas line, or use the purge button.
c) Close gas flow meter valve finger tight.
d) Turn off wire feed switch.
e) Turn off welding machine.
f) Clean the work area.

F. Other activities

1. Gather information and pictures on GMAW machines from various manufacturers for a bulletin board.

2. Determine when the purchase of a GMAW machine is justified for typical farm shop work. Determine the break-even point.

3. Put together a safety check list card for GMAW equipment.

G. Conclusion

Gas metal arc welding has many applications on and off the farm. It involves a continuous rod, a shielding gas, and the heat of electricity for easy and excellent welds.

H. Competency

Weld in all positions with MIG welder (gas metal arc welding).

a. Weld in flat position using E-70S-3 & E-71S-3
b. Weld in vertical position using E-70S-3 & E-71S-3
c. Weld in horizontal position using E-70S-3 & E-71S-3
d. Weld in overhead position using E-70S-3 & E-71S-3

I. Answers to Evaluation

1. b
2. b
3. e
4. e
5. d
6. c
7. d
8. b
9. d
10. c

Name _____

Lesson 5: Gas Metal Arc Welding (GMAW) MIG

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a term used for gas metal arc welding?

   a. MIG
   b. TIG
   c. GMAW
   d. Micro-wire
   e. Millermatic

2. Which of the following is <u>not</u> an electrical safety precaution for gas metal arc welding?

   a. Keep work area and clothing dry
   b. Dip gun in water for quick cooling
   c. Connections must be tight, clean, and dry
   d. Welder must have an earth ground
   e. Disconnect and lock power before repairing equipment

3. Which of the following is <u>not</u> a safe practice in gas metal arc welding?

   a. Shield visitors from work areas
   b. Wear long sleeved shirt and long pants
   c. Wear helmet with shaded lens
   d. Wear leather jacket or apron
   e. Wear synthetic clothing

4. The lens in the welding helmet for gas metal arc welding should <u>not</u> be lighter than number _____.

   a. 2
   b. 4
   c. 7
   d. 9
   e. 11

5. Which of the following practices is <u>unsafe</u> when gas metal arc welding?

   a. Keep cables free of kinks
   b. Do not drape cables over gas cylinders
   c. Handle gas cylinders with great caution
   d. Strike arc on gas cylinder
   e. Never drag cables

6. The electrical current and polarity for gas metal arc welding should be _____.

   a. AC reverse polarity
   b. AC straight polarity
   c. DC reverse polarity
   d. DC straight polarity
   e. Triple phase

7. Gas volume for gas metal arc welding is adjusted with the _____.

   a. Gun's trigger
   b. Voltage setting
   c. Wire speed controls
   d. Flow meter or regulator gauge
   e. Current selector

8. Which of the following metals is <u>not</u> welded with gas metal arc welding?

   a. Cast iron
   b. Aluminum
   c. Stainless steel
   d. Magnesium
   e. Carbon steel

9. Which of the following is considered a limitation for gas metal arc welding?

   a. High deposition rate
   b. Poor heat control
   c. Beginners cannot use easily
   d. Will not function well in the wind
   e. Inexpensive

10. Which is the first step in setting up equipment for gas metal arc welding?

    a. Switch wire feeder on
    b. Open gas cylinder outlet valve
    c. Check cable connections for reverse polarity
    d. Adjust welding current as desired
    e. Set wire speed feed

Demonstration Sheet 5.1: Prewelding and Postwelding Procedures for GMAW

Objective: At the completion of this demonstration, the student will be prepared to begin the job sheet in setting up, adjusting, and shutting down the gas metal arc welding machine.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers

*CAUTION: All students observing this demonstration must wear the proper eye protection. Safety precautions should be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Set the machine to Direct Current Reverse Polarity. Straight polarity should be used only when a shallow penetration is needed.

2. Plug the welding gun cable into the medium slope terminal located on the welding machine.

3. Plug the ground cable into the negative terminal on the welding machine.

4. Connect the ground cable to the table or metal to be welded.

5. Turn the welding machine power switch to "on."

6. Turn the wire feed control mechanism power switch to "on."

7. Adjust wire feed speed to zero while setting gas flow, amperage, and voltage. This will prevent wasting wire while making adjustments to gas flow.

8. Open the cylinder valve on top of the gas tank.

9. Gas flow should be adjusted to 20 to 25 cubic feet/hour (cfh). Slowly open the flow meter valve located at the top of the cylinder to adjust the amount of shielding gas being delivered to the weld area. The trigger on the welding gun should be depressed while turning the valve on the flow meter to obtain a reading.

10. Voltage should be adjusted to 19 to 21.

11. Adjust the wire feed control to provide 100 to 120 amps. A trial setting of 5 should be used for wire feed speed and adjusted accordingly in a constant voltage machine. In a machine that provides constant current, the amperage is adjusted through the voltage

setting. Check the manufacturer's manual to determine if your machine provides constant current or constant voltage. Run a practice bead to check if the correct amperage is being received. To strike an arc, squeeze the trigger on the gun at the same time that the tip of the wire touches the metal to be welded. The assistance of another person will be required to take a reading of the amperage while you are welding. You should also check for the correct voltage at this time. Increasing the wire speed will increase the amount of current provided for welding. Decreasing the wire speed will decrease the amount of current. When running a test bead, the arc should make a sizzling sound if the proper amount of shielding gas is being used.

12. Adjust the wire stickout to 1/4 to 3/8 inches. The length of stickout is measured from the welding tip to the surface of the metal to be welded.

13. Explain any additional features of your gas metal arc welding machine.

Postwelding Procedure:

1. When welding is complete, shut off the valve on the top of the gas cylinder.

2. Bleed the gas from the line by depressing the trigger on the welding gun. If the machine you are using has a "PURGE" button, pressing it will also bleed the gas from the line.

3. Close the flow meter valve on the top of the gas cylinder to finger tight. This prevents damage to the flow meter the next time the cylinder valve is opened.

4. Turn the wire feed speed switch to "OFF."

5. Turn the power switch on the welding machine to "OFF."

6. Return cables to the proper storage position.

7. Clean the work area of scrap metal.

Demonstration Sheet 5.2: Welds in the Flat Position

Objective: At the completion of this demonstration, the student will be prepared to begin the job sheet in performing butt, lap, and T-fillet welds in the flat position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students observing this demonstration must wear the proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to DS 5.1 for prewelding procedures needed to prepare for flat position welding.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the flat position.

3. The electrode should be positioned at a 90 degree work angle and a 25 to 30 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the flat position.

3. The electrode should be positioned at a 90 degree work angle and a 25 to 30 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc. If the metal exceeds 1/8 inch in thickness, the edge of the vertical plate should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the flat position.

3. The electrode should be positioned at a 45 degree work angle and a 10 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements in the welds with the students and how these improvements might be accomplished.

Postwelding Procedure: Refer to DS 5.1 for correct postwelding procedures.

Demonstration Sheet 5.3: Welds in the Horizontal Position

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet in performing butt and T-fillet welds in the horizontal position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions should be observed while working in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to Shop Demonstration 5.1 for prewelding procedures needed to prepare for horizontal position welding.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the horizontal position.

3. The electrode should be positioned at a 85 degree work angle and a 5 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the flat position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss with students possible improvements that could be made and how these improvements might be accomplished.

Postwelding Procedure: Refer to DS 5.1 for correct postwelding procedures.

Demonstration Sheet 5.4: Welds in the Vertical Position

Objective: At the completion of this demonstration, the student will be ready to begin the job sheet in performing butt, lap, and T-fillet welds in the vertical position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to DS 5.1 for prewelding procedures needed to prepare for vertical position welding.

Welding Procedure:

BUTT JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the vertical position.

3. The electrode should be positioned at a 90 degree work angle and a 10 to 15 degree push angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

BUTT JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. The vertical-down position should only be used when welding thin gauge metal since the speed of welding required will not allow for adequate penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical position.

3. The electrode should be positioned at a 90 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the vertical position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree push angle to perform the weld.

4. Lower the helmet. Strike the arc by squeezing the trigger on the gun at the same time that the tip of the wire touches the metal to be welded. Adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. The vertical-down position should only be used when welding thin gauge metal, since the speed of welding required will not allow for penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the vertical position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree push angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss with students possible improvements that could be made to the weld and how these improvements might be accomplished.

T-FILLET JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc. The vertical-down position should only be used

when welding thin gauge metal, since the speed of welding required will not allow for adequate penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical down position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

Postwelding Procedure: Refer to DS 5.1 for correct postwelding procedures.

Demonstration Sheet 5.5: Welds in the Overhead Position

Objective: At the completion of this demonstration, the student will be ready to begin the shop exercise in performing butt and T-fillet weld in the overhead position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*
6. Weld positioner

*CAUTION: All students observing this demonstration must have the proper eye protection. Safety precautions should be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to DS 5.1 for prewelding procedures needed to prepare for overhead position welding.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the overhead position.

3. The electrode should be positioned at a 90 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the overhead position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the overhead position.

3. The electrode should be positioned at a 45 degree work angle and a 10 to 15 degree drag angle to perform the weld.

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Discuss possible improvements with the students and how these improvements might be accomplished.

Postwelding Procedure: Refer to DS 5.1 for correct postwelding procedures.

Job Sheet 5.1: Prewelding and Postwelding Procedures for GMAW

Objective: At the completion of this job sheet, the student will be able to setup, adjust, and shut down the machine used for gas metal arc welding.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while working in the shop.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure:

1. Set the machine to Direct Current Reverse Polarity.
2. Plug the welding gun cable into the medium slope terminal located on the welding machine.
3. Plug the ground cable into the negative terminal on the welding machine.
4. Connect the ground cable to the table or metal to be welded.
5. Turn the welding machine power switch to "on."
6. Turn the wire feed control mechanism power switch to "on."
7. Adjust wire feed speed to zero while setting gas flow, amperage, and voltage.
8. Open the cylinder valve on top of the gas tank.
9. Gas flow should be adjusted to 20 to 25 cubic feet/hour (cfh). Slowly open the flow meter valve located at the top of the cylinder to adjust the amount of shielding gas being delivered to the weld area. The trigger on the welding gun should be depressed while turning the valve on the flow meter to get a reading.
10. Voltage should be adjusted to 19 to 21.
11. Adjust the wire feed control to provide 100 to 120 amps. A trial setting of 5 should be used for wire feed speed and adjusted accordingly in a constant voltage machine. In a machine that provides constant current, the amperage is adjusted through the voltage setting. Check the manufacturer's manual to determine if your machine is a constant voltage or constant current type. Run a practice bead to check if the correct amperage is

being delivered to the weld area. To strike an arc, squeeze the trigger on the gun at the same time that the tip of the wire touches the metal to be welded. The assistance of another person will be required to take a reading of the amperage while you are welding. You should also check for the correct voltage at this time. Increasing the wire speed will increase the amount of current provided for welding. Decreasing the wire speed will decrease the amount of current. When running a test bead, a sizzling sound should be produced by the arc.

12. Adjust the wire stickout to 1/4 to 3/8 inches. The length of stickout is measured from the welding tip to the surface of the metal to be welded.

13. Be sure all equipment is in safe working condition and that proper safety precautions are followed at all times.

Postwelding Procedure:

1. When welding is complete, shut off the valve on the top of the gas cylinder.

2. Bleed the gas from the line by depressing the trigger on the welding gun. If the machine you are using has a "PURGE" button, depressing it will also bleed the gas from the line.

3. Close the flowmeter valve on the top of the gas cylinder to finger tight. This prevents damage to the flow meter the next time the cylinder valve is opened.

4. Turn the wire feed speed switch to "OFF."

5. Turn the power switch on the welding machine to "OFF."

6. Return cables to the proper storage position.

7. Clean the work area of scrap metal.

Job Sheet 5.2: Welds in the Flat Position

Objective: At the completion of this job sheet, the student will be able to perform butt, lap, and fillet welds in the flat position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to JS 5.1 for prewelding procedures needed to prepare for flat position welding.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space of no more than 1/8 inch should be left between the metal plates to increase penetration of the weld.

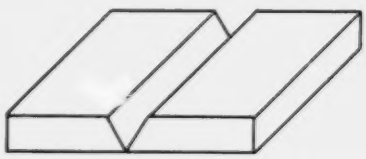


Figure 5.1

2. Position the metal so that the joint to be welded will be in the flat position. (See Figure 5.1.)

3. The electrode should be positioned at a 90 degree work angle (See Figure 5.2.) and a 25 to 30 degree drag angle to perform the weld. (See Figure 5.3.)

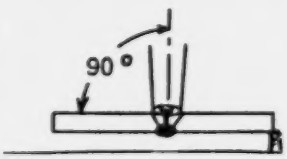


Figure 5.2

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

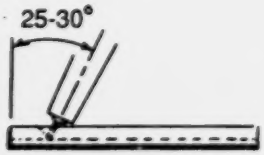


Figure 5.3

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. If the metal exceeds 1/8 inch in thickness, the edges of the joint should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the flat position. (See Figure 5.4.)

3. The electrode should be positioned at a 90 degree work angle (See Figure 5.5.) and a 25 to 30 degree drag angle to perform the weld. (See Figure 5.6.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for amount of penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

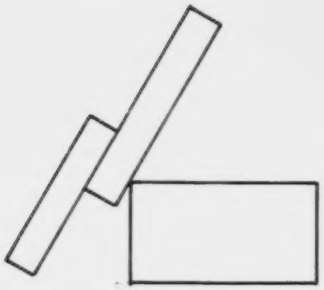


Figure 5.4

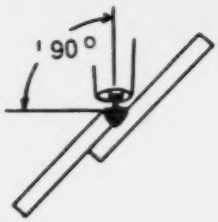


Figure 5.5

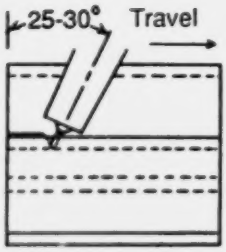


Figure 5.6

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc. If the metal exceeds 3/8 inch in thickness, the edge of the vertical plate should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the flat position. (See Figure 5.7.)

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.8.) and a 10 degree drag angle to perform the weld. (See Figure 5.9.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will increase penetration, while decreasing wire stickout will decrease the amount of penetration received.

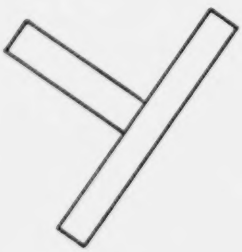


Figure 5.7

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for amount of penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

Postwelding Procedure: Refer to JS 5.1 for correct postwelding procedures.

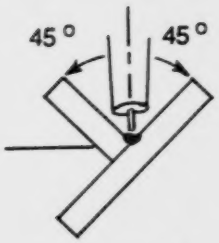


Figure 5.8

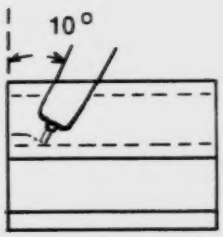


Figure 5.9

Job Sheet 5.3: Welds in the Horizontal Position

Objective: At the completion of this job sheet, the student will be able to perform a butt and T-fillet weld in the horizontal position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to JS 5.1 for prewelding procedures needed to prepare for horizontal position welding.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the horizontal position. (See Figure 5.1.)

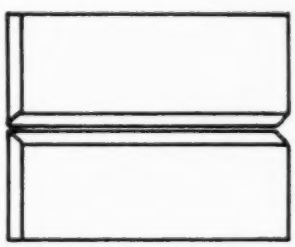


Figure 5.1

3. The electrode should be positioned at a 85 degree work angle and a 5 degree drag angle to perform the weld. (See Figure 5.2.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

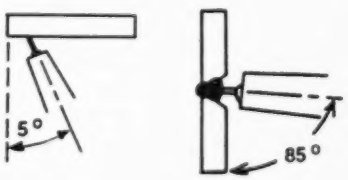


Figure 5.2

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the horizontal position. (See Figure 5.3.)

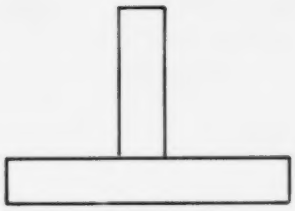


Figure 5.3

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.4) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.5.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

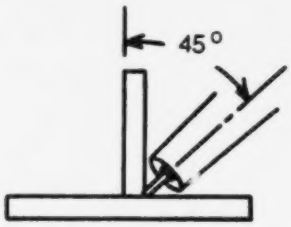


Figure 5.4

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for amount of penetration and bead appearance.

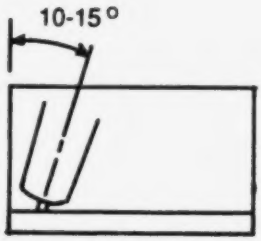


Figure 5.5

7. Turn in the weld to the instructor for grading.

Postwelding Procedure: Refer to JS 5.1 for correct postwelding procedures.

Job Sheet 5.4: Welds in the Vertical Position

Objective: At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the vertical position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to JS 5.1 for prewelding procedures needed to prepare for vertical position welding.

Welding Procedure:

BUTT JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.1.)

3. The electrode should be positioned at a 90 degree work angle (See Figure 5.2.) and a 10 to 15 degree push angle to perform the weld. (See Figure 5.3.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

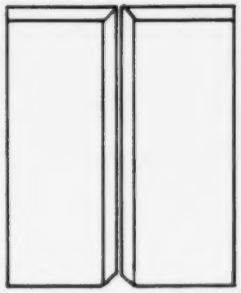


Figure 5.1

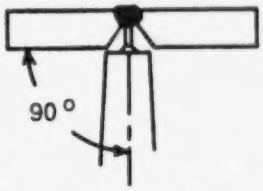


Figure 5.2

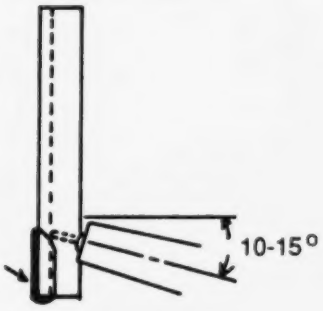


Figure 5.3

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

BUTT JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. The vertical-down position should only be used when welding thin gauge metal since the speed of welding required will not allow for adequate penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.4.)

3. The electrode should be positioned at a 90 degree work angle (See Figure 5.5.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.6.)

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical-up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

LAP JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.7.)

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.8.) and a 10 to 15 degree push angle to perform the weld. (See Figure 5.9.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while

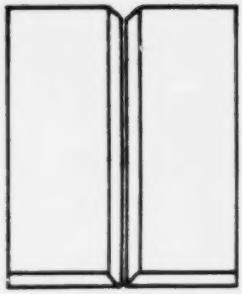


Figure 5.4

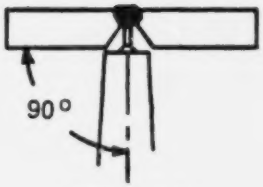


Figure 5.5

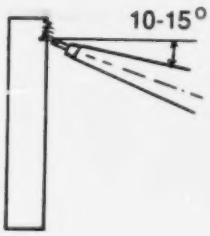


Figure 5.6

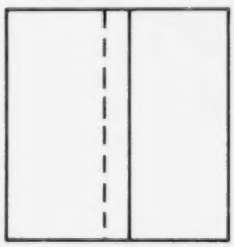


Figure 5.7

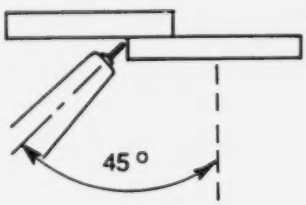


Figure 5.8

decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

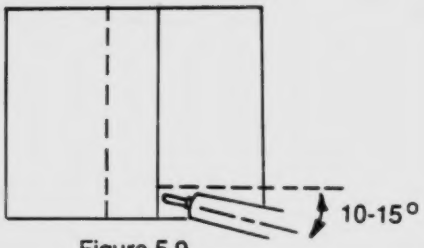


Figure 5.9

LAP JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. The vertical-down position should only be used when welding thin gauge metal since the speed of welding required will not allow for adequate penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.10.)

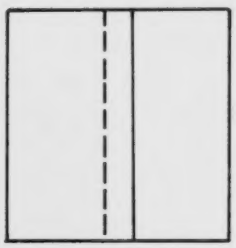


Figure 5.10

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.11.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.12.)

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

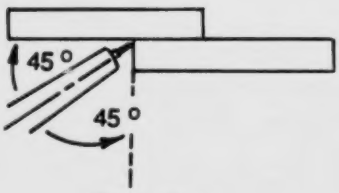


Figure 5.11

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

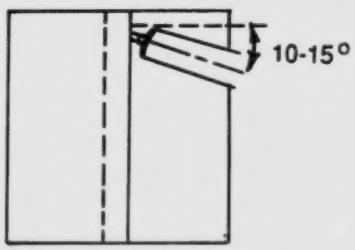


Figure 5-12

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

T-FILLET JOINT - VERTICAL UP

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.13.)

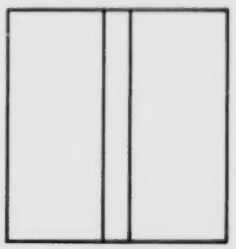


Figure 5.13

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.14.) and a 10 to 15 degree push angle to perform the weld. (See Figure 5.15.)

4. Lower the helmet. Strike the arc and adjust the length of wire to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

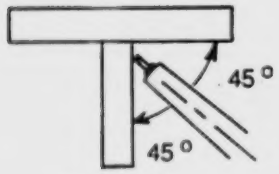


Figure 5.14

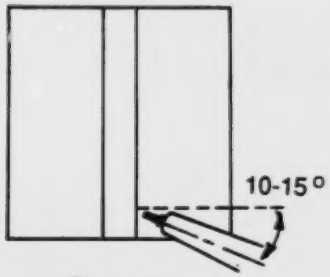


Figure 5.15

T-FILLET JOINT - VERTICAL DOWN

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc. The vertical-down position should only be used when welding thin gauge metal since the speed of welding required will not allow for adequate penetration of thicker metals.

2. Position the metal so that the joint to be welded will be in the vertical position. (See Figure 5.16.)

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.17.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.18.)

4. Lower the helmet. Strike the arc and adjust the wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld. A faster welding speed should be used than when making a vertical up weld. Welding too slowly will result in loss of control of the weld puddle and will increase the chance of burnthrough. Welding too quickly will make it difficult to maintain a stable arc, resulting in poor penetration.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

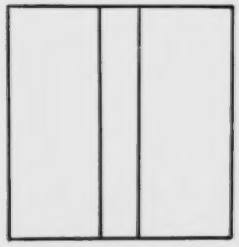


Figure 5.16

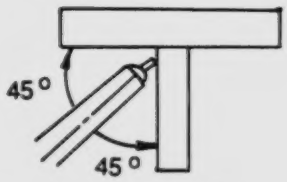


Figure 5.17

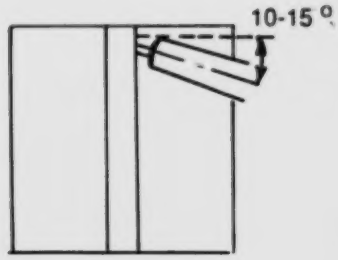


Figure 5.18

Postwelding Procedure: Refer to JS 5.1 for correct postwelding procedures.

Job Sheet 5.5: Welds in the Overhead Position

Objective: At the completion of this job sheet, the student will be able to perform a butt and T-fillet weld in the overhead position using a GMAW welder.

Tools and Equipment Needed:

1. GMAW welder
2. Protective clothing
3. Safety goggles*
4. Pliers
5. Helmet*
6. Weld positioner

*CAUTION: All students performing this procedure must wear the proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. E-70S-3 & E-71S-3 wire - .035 inch diameter
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure: Refer to JS 5.1 for prewelding procedures needed to prepare for overhead position welding.

Welding Procedure:

BUTT JOINT

Figure 5.1

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, no more than 1/8 inch, should be left between the metal plates to increase penetration of the weld.

2. Position the metal so that the joint to be welded will be in the overhead position. (See Figure 5.1.)

3. The electrode should be positioned at a 90 degree work angle (See Figure 5.2.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.3.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

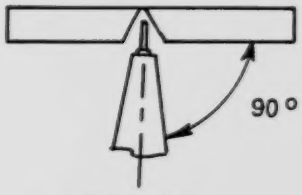


Figure 5.2

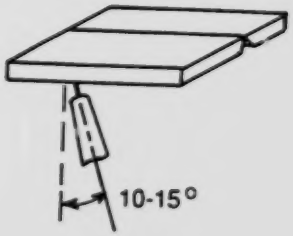


Figure 5.3

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

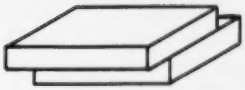


Figure 5.4

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking the arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.

2. Position the metal so that the joint to be welded will be in the overhead position. (See Figure 5.4.)

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.5.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.6.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

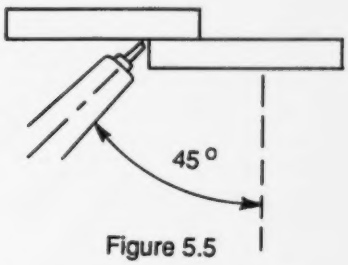


Figure 5.5

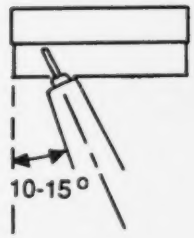


Figure 5.6

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T-joint. "Cover" should be said before striking the arc.

2. Position the metal so that the joint to be welded will be in the overhead position. (See Figure 5.7.)

3. The electrode should be positioned at a 45 degree work angle (See Figure 5.8.) and a 10 to 15 degree drag angle to perform the weld. (See Figure 5.9.)

4. Lower the helmet. Strike the arc and adjust the length of wire stickout to provide the desired penetration. Lengthening wire stickout will decrease penetration, while decreasing wire stickout will increase the amount of penetration received.

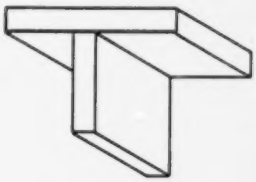


Figure 5.7

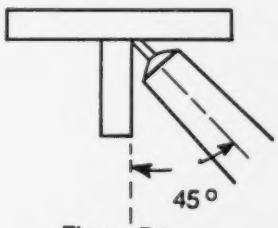


Figure 5.8

5. Maintain the proper electrode angle while using a slight weaving motion to produce the desired weld.

6. Examine the weld for amount of penetration and bead appearance.

7. Turn in the weld to the instructor for grading.

Postwelding Procedure: Refer to JS 5.1 for correct postwelding procedures.

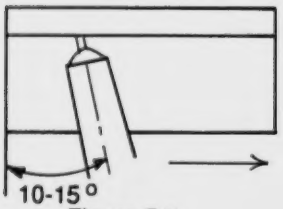


Figure 5.9

UNIT I - ARC WELDING

Lesson 6: Hardsurfacing

Objective: The student will be able to hardsurface areas where extensive wear may occur.

Study Questions

1. **What is hardsurfacing?**
2. **What kinds of metals may be hardsurfaced?**
3. **How do surfacing procedures and precautions differ for the kinds of metal to be surfaced?**
4. **What methods are available for hardsurfacing?**
5. **How is hardsurfacing accomplished with shielded metal arc welding?**
6. **What are the advantages for using arc welding for hardsurfacing?**
7. **How are surfacing electrodes normally classified, and what are some examples for the use of each category?**
8. **What is metallizing?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 6.1: Hardsurfacing
3. Demonstration Sheet
   a) DS 6.1: Hardsurfacing
4. Job Sheet
   a) JS 6.1: Hardsurfacing

UNIT I - ARC WELDING

Lesson 6: Hardsurfacing

TEACHING PROCEDURES

A. Review

Review the previous lesson on gas metal arc welding. Emphasize its application for agricultural and industrial use. Summarize how it differs from other welding methods.

B. Motivation

Bring in parts of equipment such as bucket teeth, plowshares, or cultivator sweeps that are in need of hardsurfacing. Ask students to describe the efficiency of the used parts and how they can be altered for longer life.

C. Assignment

D. Supervised study

E. Discussion

1. Hardsurfacing increases the size, hardness, and working life of machine parts and equipment. Ask students to describe the benefits of hardsurfacing. Ask for examples in agriculture when hardsurfacing is used.

   What is hardsurfacing?

   a) It is a process which gives the metal a hard, tough overlay which will resist corrosion, abrasion, and load impact.
   b) Hardsurfacing is sometimes called hardfacing.

2. All types of common steels may be hardsurfaced. Steels with a lower percentage of carbon are more apt to require hardsurfacing. List common steels on the board and categorize them as hard, which have high carbon content, and not-so-hard, which have medium and low carbon content.

   What kinds of metals may be surfaced?

   a) Metals with physical properties that are not changed during surfacing, and are not subject to cracking
      1) Low-carbon steels
      2) Medium-carbon steels
      3) Low-alloy steels
      4) Stainless steels
   b) Metals with physical properties that undergo changes during surfacing, such as undoing heat treatment and producing cracks
      1) High-carbon steels
      2) Cast irons
      3) Other alloy steels

3. Different metals require adjustment in the hardsurfacing procedure. Degree of carbon content is the influencing factor. Ask students why the hardsurfacing procedure differs for the various steels.

   How do the surfacing procedures and precautions differ for the kinds of metal to be surfaced?

   a) Metals with physical properties that are not changed need no particular precaution because no harmful cracking results.
   b) Metals with physical properties that do change need to be preheated and postheated to reduce their hardness and the possibility of harmful cracking.

4. Hardsurfacing may be accomplished in a number of ways. Heat is needed in each method. Ask students to list common methods of hardsurfacing.

   What methods are available for hardsurfacing?

   a) Oxyacetylene welding
   b) Shielded metal arc welding
   c) Hard wire and automatic welding
   d) Gas-shielded arc (MIG, TIG)
   e) Submerged arc
   f) Plasma arc

5. The arc welder is common to agricultural shops. Have students list procedures for hardsurfacing with a shielded metal arc welder.

   How is hardsurfacing accomplished with shielded metal arc welding?

   a) Use either alternating current (AC) or direct current (DC).
   b) Electrodes may be coated, solid wires, or hollow tubes containing alloy powder and flux.
   c) Thoroughly clean metal to be surfaced.
   d) Set the power supply for only enough amperage to maintain the arc.
   e) Place work in the flat position for best results.
   f) Use a medium long arc and move with a straight, weaving motion.
   g) Overlap beads.
   h) Use a whipping action along thin-edged areas.

6. Ask students under what conditions arc welding might be the best choice for hardsurfacing.

   What are the advantages for using arc welding for hardsurfacing?

   a) Fast deposition rates
   b) Wide application where large areas have to be surfaced
   c) Used where heat buildup must be restricted

7. A variety of electrodes are available specifically for hardsurfacing. Ask students to consider different agricultural and construction equipment and how the working edge's action may require different surfaces.

How are surfacing electrodes normally classified, and what are some examples for the use of each category?

a) Resistance to severe impact
   1) Dragline bucket
   2) Elevator bucket lips
b) Resistance to severe abrasion
   1) Plug mill auger
   2) Silage knives
c) Resistance to corrosion and abrasion at high temperatures
   1) Conveyor screw
   2) Arbor
d) Resistance to severe abrasion with moderate impact
   1) Cultivator sweeps
   2) Scoop lift bucket
e) Resistance to abrasion with moderate to heavy impact
   1) Shovel boom heels
   2) Pinion gear teeth

8. Metallizing differs from hardsurfacing. Special equipment is required. Introduce students to the technique of metallizing.

   What is metallizing?

   Metallizing is a spray coating process in which fine particles of metal are deposited on surfaces where metal has worn away.

F. Other activities

1. Have students give reports on maintenance and care of equipment especially for those which require hardsurfacing.

2. Make a display of equipment parts that need hardsurfacing as compared to those that have been hardsurfaced.

G. Conclusion

Hardsurfacing saves money, time, fuel, and energy when used on agricultural and industrial equipment parts. The two main methods for hardsurfacing include arc welding and oxy-acetylene welding using special rods.

H. Competency

Hardsurface areas where extensive wear may occur.

I. Answers to Evaluation

1. b
2. e
3. d
4. Answers should include five of the following:
   a. plowshare
   b. cultivator teeth
   c. dragline bucket

d. elevator bucket lips
e. plug mill auger
f. silage knives
g. conveyor screw
h. arbor
i. scoop lift bucket
j. shovel boom heels
k. pinion gear teeth

Name _____

Lesson 6: Hardsurfacing

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Hardsurfacing does not affect the physical properties of _____.

   a. High-carbon steel
   b. Medium-carbon steel
   c. High-alloy steel
   d. Medium-alloy steel
   e. Cast iron

2. Which of the following metals is most likely to crack when hardsurfaced without preheating and postheating?

   a. Low-carbon steel
   b. Medium-carbon steel
   c. Low-alloy steel
   d. Stainless steel
   e. Cast iron

3. For best results when hardsurfacing, the work should be placed in the _____.

   a. Overhead position
   b. Vertical position
   c. Horizontal position
   d. Flat position
   e. Inclined position

Complete the following short-answer question.

4. List five equipment/parts that would be hardsurfaced.

   a.
   b.
   c.
   d.
   e.

Hardsurfacing

Hardsurfacing is a process which gives the metal a hard, tough overlay which will resist corrosion, abrasion, and impact by loads. Hardsurfacing increases the size, hardness, and working life of machine and equipment parts that have worn as a result of use. Hardsurfacing is sometimes called hardfacing and can be referred to by either term.

Kinds of Metal That Can Be Hardsurfaced

Metals that can be hardsurfaced are divided into two categories. The first category includes those metals whose physical properties are not changed during the process and are not subject to cracking. These metals include low-carbon steels, medium-carbon steels, low-alloy steels, and stainless steels.

The second category of metals that may be hardsurfaced include those metals whose physical properties undergo changes during surfacing, because previous heat treatment are affected. These metals are subject to severe cracking, thus special precautions must be taken. These metals include high-carbon steels, cast iron, and other alloy steels.

Special Precautions

Metals with physical properties that are not changed during hardsurfacing need no particular precautions since no harmful cracking will result. On the other hand, metals with physical properties that are affected by hardsurfacing need to be preheated and postheated to reduce their hardness and the possibility of harmful cracking.

Methods of Hardsurfacing

Hardsurfacing may be accomplished in several ways. Among these methods are oxyacetylene welding, shielded metal arc welding, hard wire and automatic welding, gas-shielded arc welding (MIG, TIG), submerged arc welding, and plasma arc welding. Several of the above methods may not be economical in an agricultural situation, but it is important to understand the available options.

Hardsurfacing with the Shielded Metal Arc Welder

Hardsurfacing with a shielded metal arc welder (SMAW) can be accomplished using either alternating current (AC) or direct current (DC). The proper electrode should be selected for the job to be performed. Several types of electrodes are available, including coated, solid wires, or hollow tubes containing alloy powder and flux.

Before the hardsurfacing process can begin, the surface of the metal should be cleaned thoroughly of all impurities. Next, set the power supply for only enough amperage to maintain the arc. Place the metal in a flat position to begin the process. Use a medium long arc and move with a straight, weaving motion. If more than one bead is needed, the beads should overlap. A whipping motion should be used when hardsurfacing the thin edge of a surface in order to prevent burning through the edge.

Advantages of SMAW for Hardsurfacing

Though several options for hardsurfacing are available to the welder, SMAW has several advantages. A fast deposition rate allows the hardsurfacing process to move quickly, and allows the coverage of a large surface. Preheating is not necessary and heat buildup does not pose problems.

Hardsurfacing Electrodes

Hardsurfacing electrodes are classified according to resistance. The electrode chosen is based on the type(s) of resistance needed according to the use of the part.

The first category is resistance to severe impact (dragline bucket, elevator bucket lips). Impact occurs when two objects hit solidly together. Imagine the head of a cold chisel. The "mushroom" on the head is the result of repeated impact caused when the head of the hammer strikes the head of the cold chisel.

The second category is resistance to severe abrasion (plug mill auger, silage knives). Abrasion means wearing down or rubbing away by friction. When two metals rub against each other, eventually friction will begin to wear away the surface.

The third category is resistance to corrosion and abrasion at high temperatures (conveyor screw, arbor). Corrosion means the process of dissolving or wearing away. Rust is one of the most common types of corrosion.

The fourth category is resistance to severe abrasion with moderate impact (cultivator sweeps, scoop lift bucket).

The fifth category is resistance to abrasion with moderate to heavy impact (shovel boom heels, pinion gear teeth).

Metallizing

Metallizing is a spray coating process in which fine particles of metal are deposited on surfaces where metal has worn away. Large areas can be surfaced by metallizing. Applying a dissimilar metal coating is allowed.

Demonstration Sheet 6.1: Hardsurfacing

Objective: At the end of this demonstration, the student should be prepared to begin the hardsurfacing job sheet.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Peening hammer
7. Chipping hammer
8. Grinder

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions should be observed while in the shop area.

Materials Needed:

1. Mild steel plate - size to be determined by instructor
2. 1/8" hardsurfacing electrode (work-hardening type, impact resistant)

Prewelding Procedure:

1. Clean and grind the surface of the metal. Safety goggles and face shield must be worn when operating the grinder.

2. Lay the metal in the flat position on the welding table.

3. Set amperage at 90-120 amps.

Welding Procedure:

1. Lower your helmet and strike the arc. "Cover" should be said before striking the arc. Maintain a moderately long arc.

2. Use a weaving pass to lay the bead. The bead should be 3/4" wide and 1/16" thick.

3. Peen the weld to increase hardness.

4. With safety goggles on, remove slag from the weld.

5. Examine the bead for correct result.

6. Return all equipment to proper storage position and clean the work area.

Job Sheet 6.1: Hardsurfacing

Objective: At the end of this job sheet, the student should be able to correctly hardsurface in the flat position.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer
8. Grinder
9. Peening hammer

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Mild steel plate - size to be determined by instructor
2. 1/8" hardsurfacing electrode (work hardening type, impact resistant)

Prewelding Procedure:

1. Remove all dirt, oil, and grease from the surface of the metal.

2. Safety goggles and face shield must be worn when using the grinder. Grind the surface of the metal to remove any additional impurities and improve cohesion of the molten metal.

3. Lay the metal plate in a flat position on the welding table.

4. Set amperage to 90-120 amps. The amperage should be set as low as possible to maintain an arc. Excessive penetration of the metal should be avoided.

Welding Procedure:

1. Lower the helmet and say "Cover." Strike an arc at the edge of the plate and maintain a moderately long arc (approximately 1/4").

2. A weaving pass should be used to deposit the beads on the plate. The beads should be approximately 3/4" in width and 1/16" thick. (See Figure 5.1.)

   NOTE: Excessive thickness of the hardsurfaced bead can result in cracking and chipping when the part comes into contact with abrasion or impact. Avoid excessive

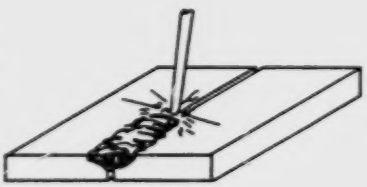


Figure 5.1

penetration when welding along thin edges to avoid burnthrough.

3. Using a peening hammer, strike the surface of the bead to increase the hardness of the weld.

4. After the weld has cooled, remove slag. Safety goggles must be worn.

5. Examine the bead. It should be smooth and evenly deposited.

6. Turn in weld to instructor.

7. Replace all equipment to proper storage position and clean the work area.

UNIT I - ARC WELDING

Lesson 7: Welding Cast Iron

Objective: The student will be able to weld cast iron with the shielded metal arc welder.

Study Questions

1. **What is cast iron, and how is it used?**
2. **What are the five common types of cast iron?**
3. **How is cast iron prepared for welding?**
4. **What electrodes are used to successfully weld cast iron?**
5. **What is preheating, and how is it accomplished?**
6. **What is the welding procedure for arc welding cast iron?**
7. **What is heat treatment, and why is it necessary in welding cast iron?**

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 7.1: Welding Cast Iron
3. Demonstration Sheet
   a) DS 7.1: Welding Cast Iron
4. Job Sheet
   a) JS 7.1: Welding Cast Iron

UNIT I - ARC WELDING

Lesson 7: Welding Cast Iron

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Bring in molds used for iron casting. Briefly explain the process to students. Ask them to name cast iron machinery parts with which they are familiar. What are the advantages and limitations of cast iron? Lay out types of cast iron. Ask students to explain the differences.

C. Assignment

D. Supervised study

E. Discussion

1. Compare the costs of properly repairing a cast iron machine part versus purchasing a new part. Ask students to name items that are made of cast iron.

   What is cast iron, and how is it used?

   a) Cast iron is an alloy of iron, carbon, and silicon (sometimes manganese, sulfur, and phosphorus).
   b) Carbon content ranges from 1.8 to 4 percent.
   c) Cast iron refers to a wide range of products.
      1) Some are rough, brittle, and weak, such as window sash weights.
      2) Others are strong and high quality, such as cylinder blocks, crankshafts, and pump bodies.

2. Cast iron is classified into five common types. Using samples of the types, ask students to compare and determine uses for each type of cast iron.

   What are the five common types of cast iron?

   a) White cast iron (e.g., steam radiators, iron rolls for mills)
   b) Gray cast iron (e.g., implement frames, engine blocks)
   c) Malleable cast iron (e.g., implements, automobiles, bearing caps, wheel hub, steering housings)
   d) Alloy cast iron (e.g., machine tools, cylinders, pistons, piston rings)
   e) Nodular or ductile cast iron (e.g., machinery parts, wheel spindle, spindle support, ring gear, pinion)

3. Although cast iron is quite different from mild steel, many of the same prewelding steps are followed. Additional precautions must be followed to achieve a satisfactory weld. Display cast iron parts that failed to be repaired because of poor preparation. Ask students what steps the welder should have taken to prevent such weld failure.

How is cast iron prepared for welding?

a) Remove impurities by grinding off the surface layer of the metal known as the casting skin.
b) Wire brush the cast iron and clean with detergent solution to remove rust, scale, dirt, and oil.
c) Thin pieces should be cleaned by grinding.
d) Thick pieces of 1/8 inch or more should be beveled at a 60 degree angle, leaving a 1/16-inch root face.
e) Grinding residues left should be brushed off by wire brush or filing.
f) To prevent cracks from enlarging, small holes should be drilled beyond the ends of the crack.
g) Malleable and nodular cast iron should be preheated and postheated when welding.

4. Pass out several kinds of electrodes to students. Allow them to inspect the electrodes for numbers and letters. Write the different types on the board. Circle the electrodes that are used for welding cast iron.

What electrodes are used to successfully weld cast iron?

a) Machinable electrodes are used for repairing broken castings, filling up defects, correcting machine errors, or welding cast iron to metal.
   1) Nickel cast iron electrode (ENi-CI)
   2) Nickel-iron cast iron electrode (ENi-FeCI)
b) Non-machinable electrodes produce a tight, waterproof weld; yet a very hard deposit is not to be machined.
c) Electrodes of nickel, nickel alloy, mild steel, or nickel-copper-iron alloy are used in shielded metal arc welding of cast iron.
d) Nickel-copper-iron alloy electrodes such as ENiCu-A and ENiCu-B are also used to weld cast iron.

5. Show students a furnace used to preheat and postheat metal. Ask them about heating and cooling time and how it can affect metals. How can metal be heated without a furnace and thermostat?

What is preheating, and how is it accomplished?

a) Preheating is the heating of metal before it is welded.
b) The metal is placed in a furnace and heated to a specified temperature or heated with an oxy-fuel gas torch.
   1) Cast iron to be shield metal arc welded (SMAW) should be heated to a temperature of 400 F to 600 F.
   2) Preheating prevents cracking by eliminating stress on the metal during the welding process.

6. Ask students why following the procedure for welding cast iron is important.

What is the welding procedure for arc welding cast iron?

a) Preheat the casting in a furnace.
b) Set the machine for the correct amperage.
c) Use small diameter electrodes to keep heat to a minimum.

d) Slant the electrode 5 to 10 degrees in the direction of travel and deposit straight beads.
e) Use a slightly longer arc than used in welding mild steel.
f) Do not deposit a bead with a width of more than three times the diameter of the electrode.
g) Use a back-step welding technique.
h) Use either alternating current (AC) or direct current reverse polarity (DCRP).
i) Reinforce heavy castings with studs for added strength.
j) Run short beads of 1 inch to 1.5 inches on thin metal and 2 inches to 3 inches on heavy metal.
k) Heat treat the casting immediately following welding.

7. The job is not truly complete when the welding machine is turned off. Slow cooling of metal is necessary for proper strength. Ask students to compare cooling methods. Why is slow cooling best for the strength of metal?

What is heat treatment, and why is it necessary in welding cast iron?

a) Heat treatment is the heating of metal after welding.
b) The heat treatment of cast iron relieves the stresses from welding.
c) Heat treatment prevents brittle white cast iron from forming.
d) Heat treatment is accomplished by placing the welded casting immediately into a furnace and heating it to 1,100 F. The temperature is held for one hour for each inch of thickness and then slow cooled in the furnace.

F. Other activities

1. Collect samples of different types of cast iron to exhibit as a teaching aid.

2. Make a list of uses of cast iron items in the agricultural shop and on the farm.

3. Assign students written or oral reports on how cast iron is made.

4. Visit a foundry to view how metals are manufactured.

G. Conclusion

Cast iron is important to modern agriculture. Both its strength and endurance are needed for construction and repair of structures, equipment, and parts. Special procedures must be followed to successfully weld cast iron.

H. Competency

Weld cast iron.

I. Answers to Evaluation

1.	a	5.	c
2.	c	6.	d
3.	e	7.	c
4.	a	8.	a

Name _____

Lesson 7: Welding Cast Iron

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. The main components of cast iron include _____.

   a. Iron, carbon, and silicon
   b. Iron, steel, and magnesium
   c. Aluminum and tin
   d. Carbon, boron, and tungsten
   e. Iron, carbon, and molybdenum

2. Which of the following is <u>not</u> a type of cast iron?

   a. White cast iron
   b. Gray cast iron
   c. Pig cast iron
   d. Malleable cast iron
   e. Ductile cast iron

3. To prevent cracks from enlarging when welding cast iron, it is recommended to _____.

   a. Grind the area
   b. Clamp the workpiece
   c. Coat area with dye
   d. Preheat the workpiece
   e. Drill small holes

4. The surface layer of cast iron is known as _____.

   a. Casting skin
   b. Pig skin
   c. Outer casting
   d. Sand liner
   e. Pickle liner

5. Which of the following electrodes would <u>not</u> be suitable for use in welding cast iron?

   a. ENi-Cl
   b. ENi-FeCl
   c. E7018
   d. ENi-CuA
   e. ENi-CuB

6. Cast iron should be preheated before it is welded to what temperature?

   a. 100 degrees F
   b. 200 degrees F
   c. 300 degrees F
   d. 500 degrees F
   e. 1000 degrees F

7. The arc length for welding cast iron as compared to the arc length for welding mild steel is _____.

   a. Shorter
   b. The same
   c. Slightly longer
   d. Two times longer
   e. Three times longer

8. The electrode should be slanted to what degree in the direction of travel when welding cast iron?

   a. 10 degrees
   b. 25 degrees
   c. 35 degrees
   d. 40 degrees
   e. 60 degrees

Characteristics and Uses of Cast Iron

Cast iron is used extensively in both the manufacturing and agricultural industries. Cast iron differs from mild steel in that it is brittle and breaks more easily. Cast iron possesses characteristics that make it difficult to weld. Cast iron is an alloy of iron, carbon, and silicon. Some types contain a small percentage of sulfur, phosphorus, and manganese. The carbon content ranges from 1.8 percent to 4 percent. Some types of cast iron are rough, brittle, and weak (e.g., window sash weights), while others are strong and high quality (e.g. cylinder blocks, crankshafts, and pump bodies).

Types of Cast Iron

There are five common types of cast iron. The correct procedure for welding each type of cast iron may differ. It is important to understand these differences so that the correct welding procedure will be followed. White cast iron is extremely hard; its use is limited to only a few applications, such as steam radiators. Gray cast iron is the most commonly used type because of its machinability and strength. Gray cast iron is used in the manufacture of implement frames and engine blocks.

Malleable cast iron is used in the manufacture of implements and automobiles. It possesses characteristics similar to low-carbon steel and must be heat treated when welding. Alloy cast iron is similar to gray cast iron except that additional alloy metal is added to improve strength and machinability. Because of the added alloy, this type of cast iron is higher priced. Nodular cast iron, also known as ductile cast iron, possesses high strength, machinability, and resistance. Preheating and postheating is required when welding.

Preparing Cast Iron for Welding

Cast iron possesses certain characteristics that make it difficult to weld. At one time, brazing was the only effective method of welding cast iron. Since that time, special coated electrodes have been developed which will allow the use of an arc welding machine to weld cast iron. Before welding can be done, there are several preparations which must be done to achieve a high quality weld. The outer layer of cast iron, known as the casting skin, must be removed before welding. All rust, scale, dirt, and oil should be removed. Grinding is the preferred surface preparation method.

To improve the strength of the weld, cast iron greater than 1/8" thick should be beveled on the edges to allow a stringer bead to be placed in the joint. Cast iron is very susceptible to cracking during the welding process. If the weld being made is to repair a crack, a small hole should be drilled at each end of the crack to prevent further cracking. To prevent cracking and distortion of the weld, malleable and nodular cast iron should be preheated or postheated when welding.

Electrodes

Cast iron electrodes are classified as machinable and non-machinable. Machinable electrodes include nickel-cast iron (ENi-CI) and nickel-iron cast iron (ENi-FeCI) and are used for repairing broken castings, for filling up defects, for correcting machine errors, and for welding cast iron to metal. Non-machinable electrodes produce a tight, waterproof weld that cannot be machined. Nickel, nickel alloy, mild steel, or nickel-copper-iron alloy electrodes are used in shielded metal

arc welding. Nickel-copper-iron alloy electrodes, such as ENiCu-A and ENiCu-B, are also used to weld cast iron.

Preheating

Preheating means heating metal before it is welded. The metal may be placed in a furnace and heated to a specified temperature, or heated with an oxy-fuel torch. Preheating eliminates stress on the metal at welding and prevents cracking. Cast iron to be shield metal arc welded should be heated to a temperature of 400 F to 600 F.

Heat Treatment

Heat treatment is the heating of metal after it is welded. The heat treatment of cast iron relieves the stress from welding and prevents brittle white cast iron from forming. Heat treatment is accomplished by placing the welded casting immediately into a furnace and heating it to 1100 F. The temperature is held for one hour for each inch of thickness and then slow cooled in the furnace.

Demonstration Sheet 7.1: Welding Cast Iron

Objective: At the end of this demonstration, the student should be prepared to begin the job sheet on welding cast iron.

Tools and Equipment Needed:

1. AC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Cast iron (machinable or non-machinable)
2. 1/8 inch cast iron type electrode (machinable or non-machinable)

Prewelding Procedure:

1. Break the cast iron into several pieces.
2. Prepare a V-joint in the cast iron.
3. Remove the casting skin along the joint. Use safety goggles and a face shield when using the grinder.
4. Select the correct electrode according to the type of cast iron.
5. Set the amperage to 100 amps.
6. Run a trial bead and adjust the amperage accordingly.

Welding Procedure:

1. Lower your helmet and say "Cover." Strike an arc and adjust the length.
2. Run a stringer bead in the bottom of the joint.
3. Clean the slag from the weld and allow the weld to cool.
4. Repeat Steps 2 and 3.
5. Clean and examine the weld.

Job Sheet 7.1: Welding Cast Iron

Objective: At the end of this job sheet, the student should be able to weld cast iron.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Cast iron (machinable or non-machinable)
2. 1/8 inch cast iron type electrode (machinable or non-machinable)

Prewelding Procedure:

1. Break the cast iron into several pieces.

2. If the cast iron exceeds 1/8", one side should be ground to a 60 degree angle. Leaving a shoulder edge at the bottom of the joint will help when realigning the parts.

3. To remove the casting skin, grind the cast iron along the joint to be welded. Safety goggles and a face shield must be worn.

4. Select the correct electrode according to the type of cast iron.

5. Set the amperage at 90 to 120 amps. A trial setting of 100 amps should be used. A smooth, even deposit will result if amperage is correct. If excessive pile up occurs, the amperage should be reduced. Increase the amperage if bubbles appear in the weld or burnthrough occurs.

6. If using a DC welder, the machine should be set to DCRP.

Welding Procedure:

1. Lower your helmet and say "Cover" before striking the arc. Use a scratching method to establish the arc. A slightly longer arc is needed than when welding mild steel. If the electrode metal drops off in globules, lower the electrode slightly.

2. Lay a stringer bead in the bottom of the V-joint. The electrode should be angled 5 to 10 degrees in the direction

of travel. Molten metal is deposited in the direction of travel. Position the electrode so that both sides of the joints are fused. Do not deposit a bead with a width of more than three times the diameter of the electrode. Avoid overheating the metal by allowing it to cool between passes. (See Figure 7.1.)

3. Complete the weld by laying single pass beads to fill the joint. Remember to allow cooling time between welds. Run short beads of 1 to 1 1/2 inches on thin metal and 2 to 3 inches on heavy metal. (See Figure 7.2.)

4. Clean and examine the weld. Make sure that the deposited metal is fused into the base metal. Check for small holes in the surface of the bead.

5. Turn the weld into the instructor for grading.

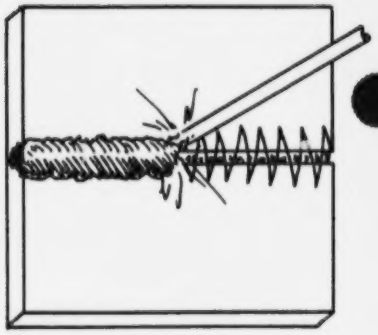


Figure 7.1

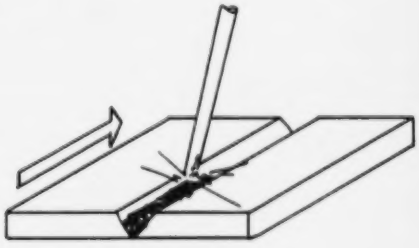


Figure 7.2

UNIT I - ARC WELDING

Lesson 8: Pipe Welding

Objective: The student will be able to weld pipe for agricultural construction and repair.

Study Questions

1. What are the advantages and disadvantages of using pipe in agricultural construction?
2. Why is black pipe preferred over galvanized pipe for welded projects?
3. How should pipe be prepared for welding?
4. What electrode positions are used when welding pipe?
5. How are butt joints and T-joints laid out for welding pipe?
6. How can angles for pipes be laid out with accuracy?
7. What are two methods for closing the ends of pipe?
8. What is the procedure for welding a butt joint when the pipe can be repositioned?
9. What is the procedure for welding a butt joint when the pipe cannot be repositioned?

References

1. Giachino, Joseph W.; William Weeks. Welding Skills. Alsip, NY: American Technical Publishers, Inc., 1985.
2. Handout
   a) HO 8.1: Welding Pipe
3. Demonstration Sheets
   a) DS 8.1: Pipe Welding T-joints
   b) DS 8.2: Laying Out Angles
   c) DS 8.3: Closing the End of Pipe
   d) DS 8.4: Butt Joint - Repositioned
   e) DS 8.5: Butt Joint - Not Repositioned
4. Job Sheets
   a) JS 8.1: Pipe Welding T-joints
   b) JS 8.2: Laying Out Angles
   c) JS 8.3: Closing the End of Pipe
   d) JS 8.4: Butt Joint - Repositioned
   e) JS 8.5: Butt Joint - Not Repositioned

UNIT I - ARC WELDING

Lesson 8: Pipe Welding

Objective: The student will be able to weld pipe for agricultural construction and repair.

TEACHING PROCEDURES

A. Review

Review the previous lesson on welding cast iron.

B. Motivation

Bring in projects made with pipe or photographs of such projects that would be useful to the student. Sample projects may include gates, truck racks, chutes, and feeders. Discuss availability and suitability of pipe as a construction material. Briefly discuss pipe welding procedures and possible pipe welding problems.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students to list uses of pipe on the farm or in the shop. How available is pipe for construction? What are the advantages and disadvantages of using pipe for projects?

   What are the advantages and disadvantage of using pipe in agricultural construction?

   a) Advantages
      1) Strong
      2) Readily available
      3) Relatively inexpensive
      4) Comes in standard sizes
      5) Lightweight in relation to strength
   b) Disadvantages
      1) Extra skills are required for proper cutting, fitting, and welding.
      2) Welding positions must be changed often to weld pipe.

2. Bring in samples of pipe of various sizes and types. Discuss different materials, inside diameters, outside diameters, strength, and suitability. Ask students to identify samples.

   Why is black pipe preferred over galvanized pipe for welded projects?

   a) Galvanized metal gives off toxic fumes when welded; therefore, it must be ground to remove the zinc coating before welding.
   b) Black pipe is more economical than galvanized pipe.
   c) Black pipe is easier to weld than galvanized pipe.

3. Show students how difficult welding is on rusty metal as compared to properly prepared metal. Ask students to name tools and equipment that would be helpful in preparing metal for welding.

How should pipe be prepared for welding?

a) Rust, grease, paint, dirt, and other foreign material should be removed from pipe.
b) The area to be welded should be ground until it is shiny.
c) Pipe over one-eighth inch thick should be beveled before welding.
d) Trial welds should be made to determine the correct amperage to use.
e) Pipes should be properly aligned before tack welding.
f) Correct tack welding procedures should be followed to control contraction forces from the weld.

4. Using clamps or fixtures, set up pipes for welding a butt or T-joint. With a rod in the holder, show students positions used when welding pipe. Explain that if the pipe cannot be moved, more than one welding position will usually be required when welding the joint.

What electrode positions are used when welding pipe?

a) Flat
b) Vertical
c) Horizontal
d) Overhead

NOTE: Most agricultural construction and repair jobs will require to the use of a combination of the above positions.

5. Show students a set of short pipes to be welded using butt joints and T-joints. Include sets at various stages such as beveled, tacked, partially welded, and completely welded. (See DS 8.1 and JS 8.1.)

How are butt joints and T-joints laid out for welding joints?

a) Butt joints
   1) Butt the ends of the pipe together while leaving a small space between pieces for deeper penetration.
   2) Use a liner or a backup ring inside the pipes to weld them together.
b) T-joints
   1) Flatten-end method
   (a) Flatten the end of the pipe to allow a good fit.
   (b) Pipe is tack welded on opposite sides of the pipe to counteract distortion.
   (c) Complete weld.
   2) Cut-and-fit method
   (a) Quarters of the pipe are marked with soapstone.
   (b) Sections of the pipe are cut or ground off for proper fit.
   (c) Pipe is tack welded at four even points to counteract distortion.
   (d) Complete weld.

6. Angles of 90, 60, 45, and 30 degrees are common to agricultural construction and may be used in welding pipe. Ask students how these angles may be transferred to pipe. Are there simpler techniques? (See DS 8.2 and JS 8.2.)

   How can angles for pipes be laid out with accuracy?

   a) The following tools can be used to lay out pipe.
      1) Framing square
      2) Sliding T-bevel
      3) Protractor
      4) Dividers
   b) A fixture can be made to aid layout.
   c) A line drawing chalked on a floor may be helpful.
   d) A bucket of water may be used to mark pipe for desired angle to be cut.

7. Often, closing the ends of pipes used in project construction will give the project a better appearance and make it last longer. Ask students what two methods may be used to close the end of a pipe. (See DS 8.3 and JS 8.3.)

   What are two methods for closing the ends of a pipe?

   a) Weld a circular piece of plate to the end of the pipe.
   b) Use an orange-peel plug to close the end of the pipe.

8. Pipe welding in agricultural construction and repair jobs can sometimes be difficult because of the need to change welding positions. Ask students how this problem might be avoided. (See DS 8.4 and JS 8.4.)

   What is the procedure for welding a butt joint when the pipe can be repositioned?

   NOTE: The procedure is listed on D.S. 8.4.

9. When a large or bulky project or piece of equipment is being welded, it is not always possible to reposition the pipe for welding. Ask students how this problem can be overcome. (See DS 8.5 and JS 8.5.)

   What is the procedure for welding a butt joint in pipe when the pipe cannot be repositioned?

   NOTE: The procedure is listed on D.S. 8.5.

F. Other activities

1. Construct a wind chime using various types and sizes of pipe.

2. Collect and file project plans made of pipe.

3. Have students design fixtures that could be used to bend, cut, or weld pipes at common angles.

4. Have students design and construct a telescoping object using two sizes of pipe.

G. Conclusion

Using pipe for projects in agricultural construction is common because of the availability, economy, and strength of pipe. Extra skill is required for welding pipe compared to welding other shapes of stock.

H. Competency

Weld pipe.

I. Answers to Evaluation

1. d
2. c
3. d
4. e
5. c
6. d

Name _____

Lesson 8: Pipe Welding

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Pipe is often used for agricultural construction because it is _____.

   a. Heavyweight
   b. Easy to work with
   c. A material that requires no special skill to weld
   d. Commonly available and strong
   e. Expensive and lightweight

2. Galvanized pipe is <u>not</u> preferred over black pipe for welded projects because galvanized pipe _____.

   a. Is not usually available
   b. Melts quickly
   c. Gives off toxic fumes when welded
   d. Cannot be threaded
   e. Cannot be painted

3. Which of the following is <u>not</u> true in preparing pipe to be welded?

   a. Grease and other foreign material should be removed.
   b. Sand paper or a sanding disc may be useful.
   c. Pipe over 1/8" in wall thickness requires beveling.
   d. Use flat, vertical, horizontal, and overhead positions.
   e. A grinder or wire brush aids in weld preparation.

4. At what point(s) is a pipe T-joint tack welded to compensate for stress?

   a. Left side only
   b. Center only
   c. Top of T
   d. Right side only
   e. Four even points

5. Which method of making a pipe T-joint requires only straight cutting?

   a. Cut and butt method
   b. Smash and weld method
   c. Flatten-end method
   d. Cut and fit method
   e. Cut and squish method

6. How is a bucket of water used for laying out pipe to be welded?

   a. Quick cooling
   b. Quenching
   c. Removing old lines
   d. Marking angles around entire pipe
   e. Cleaning out layout area

Advantages and Disadvantages

Pipe is commonly used in many agricultural construction and repair jobs. It is used primarily because it is strong, readily available, and relatively inexpensive. Pipe comes in standard sizes and is lightweight in relation to its strength. Cutting, fitting, and welding of pipe is more difficult than flat metal since changing welding positions is often necessary. However, with adequate knowledge and practice, agricultural workers can learn the skills and abilities necessary to successfully weld pipe.

Types of Pipe

Two types of mild steel pipe are commonly available - black and galvanized. Black pipe is often used to carry natural gas, air, and steam. Black pipe is more economical and easier to weld than galvanized pipe. Galvanized pipe, commonly used to carry water, is coated with zinc to resist corrosion. The zinc coating makes the pipe more difficult to weld than black pipe. The heat from the welding process produces poisonous zinc fumes; therefore, adequate ventilation is always required when welding or heating galvanized pipe. Galvanized pipe should be ground whenever possible to remove the zinc coating prior to welding or heating. If it is not possible to remove the zinc coating, the use of multiple-pass beads will result in stronger welds with less porosity than single-pass beads.

Preparing Pipe for Welding

In order to get the best welds on pipe, the joint should be clean and free from grease, paint, dirt, rust, zinc, and all other foreign materials. If possible, the area to be welded should be ground until it is shiny. If pipe wall thickness exceeds 1/8 inch, the joint edges should be beveled.

Amperage should be set so that adequate penetration is achieved, but not so high that the weld burns through the pipe. Correct amperage should be determined by trial on a scrap piece of pipe equal in size to the pipe to be welded.

Care should be taken to insure that pipes are properly aligned prior to tack welding. The use of jigs or other holding devices will make alignment easier. Four tack welds should be made rapidly on alternate sides of the pipe in order to counteract distortion. The pipes should be rechecked for proper alignment after tack welding. If they are out of line, the tack welds should be ground down and the pipe should be realigned and tack welded again.

Welding Positions for Pipe Joints

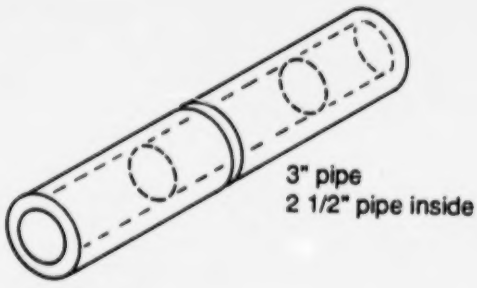
Pipes are commonly welded in the flat, horizontal, vertical, and overhead positions. Since the surface of the pipe is circular, some pipe joints will be welded in more than one of these positions. Pipes that cannot be repositioned may require a combination of two or more positions.

Laying Out Butt Joints

Butt joints are not difficult to lay out. In a butt joint, two pieces of pipe are welded together end to end. Pipes with 1/8-inch or less wall thickness are simply butted together with a small separation to permit proper penetration. The ends of pipes with wall thickness greater than 1/8 inch should be beveled to approximately a 70 degree angle. Size of the required root face and root opening will vary depending on pipe size. (See Figure 8.1.)

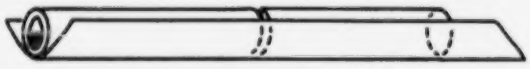
Figure 8.1

Figure 8.2



Burnthrough problems can be reduced by placing a liner or backup ring inside the two pipes being welded. Satisfactory backup rings can be made by cutting short sections from the next smallest size of pipe. (See Figure 8.2.)

Figure 8.3



Pipes may be properly aligned for tacking by placing them in a piece of angle iron. (See Figure 8.3.)

Laying Out T-joints

T-joints are formed when two pipes are welded together in the shape of the letter "T." When pipes are joined in a tee joint, the vertical pipe is called the "branch" and the horizontal pipe is called the "header."

Figure 8.4

Figure 8.5

Two methods can be used to fit pipes into a T-joint. The quickest and easiest method is to simply flatten the end of the branch pipe and weld it to the header pipe. This flattening is usually done with a sledge hammer while the pipe is cold. The branch pipe should only be flattened enough to ensure a proper fit, since excessive flattening will weaken the pipe. The joint should be properly aligned and tack welded on opposite sides to counteract contraction forces of the metal. A bead should be run the entire length of the joint. (See Figure 8.4.)

The second method of laying out a T-joint involves cutting the branch pipe so that it will fit around the header pipe, as illustrated in Figure 8.5. To make a proper fit, the end of the branch pipe should be divided into four equal sections and marked with soapstone. Sections of the pipe should be cut or ground so that the branch pipe will fit snugly onto the header pipe. Tack welds should be made on all four sides and a bead laid the entire length of the joint.

Laying Out Angles on Pipe

Ell joints are made on pipe when an angle in the pipe is needed. There are several methods for accurately laying out angles. Several tools, such as a framing square, a sliding T-bevel, a protractor, and dividers, are used to assist in making the correct angle. A fixture can be made to use as a pattern for laying out angles. A line drawing chalked on the floor may be helpful. A simple method used in laying out an angle joint uses a container of water and a measuring device such as a square or a T-bevel. As illustrated in Figure 8.6, the pipe is placed in position using a T-bevel to adjust the pipe to the desired angle.

Figure 8.6

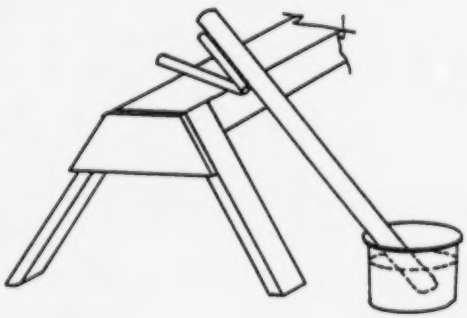


Figure 8.7

Closing the Ends of Pipe

In many agricultural construction and repair jobs it may be necessary to close the ends of pipes. This gives the project a better appearance and prevents water from entering the pipes. Two methods are commonly used to close the ends of pipes.

The easiest method is to cut a circle from a plate of metal and weld it to the end of the pipe. This is a quick and effective way to close the end of a pipe; however, it does not produce the most attractive project. The second method is called the "orange-peel plug." Though this method is more time-consuming, it will produce a more attractive pipe end. (See Figure 8.7.)

If an orange-peel plug pipe must be an exact length, make the plug first and then cut the opposite end of the pipe to achieve the desired length.

Welding Pipe That Can Be Repositioned

In many agricultural construction and repair jobs the pipe to be welded can be partially welded and then repositioned. This type of pipe welding is easier because the weld can be made in a more comfortable and efficient manner.

Welding Pipe That Cannot Be Repositioned

In some construction and repair operations, the pipe is in a stationary position and cannot be repositioned. These welding situations are generally more difficult and call for different welding techniques. The technique will vary depending on the position of the pipe.

When pipe is welded in the vertical position, the pipes are placed on a horizontal plane, causing the joint to be welded to be in the vertical position. Pipes in this position can be welded either vertical-down (downhill) or vertical-up (uphill), depending on wall thickness and service requirements. The vertical-down method is well-suited for welding thinner pipe and pipes which are not subject to heavy service requirements.

Demonstration Sheet 8.1: Pipe Welding T-joints

Objective: At the completion of this demonstration, the student will be ready to weld pipe T-joints used in agricultural construction and repair.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer
8. Soapstone
9. Grinder

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 electrodes - 1/8 inch

NOTE: Two methods of laying out and welding a T-joint are addressed in this demonstration. Prewelding procedures are given for both methods.

Prewelding Procedure:

FLATTEN END METHOD

1. Cut two pieces of pipe to the desired length.
2. Flatten the end of the branch pipe.
3. Grind and bevel the end of the branch pipe if necessary.
4. Position the pipes in the flat position on the welding table.
5. Use a square to check the joint for accuracy.
6. Set amperage on the welder to 120-150 amps.

CUT AND FIT METHOD

1. Divide the circumference of the pipe into four equal sections and mark with a center punch.
2. Align points A and C with the imaginary center line of the header pipe. Measure the gap distance form point B or D to the branch pipe.

3. Use a ruler to move points A and C from the end of the pipe to a distance equal to the gap measured in Step 2.

4. Use soapstone to connect points A, B, C, and D with arcing lines.

5. Cut along the soapstone line with an oxy-fuel torch.

6. Dress the cut with a grinder for a better fit.

7. Bevel the edge of the pipe if necessary. Be sure to wear safety goggles and a face shield when grinding.

8. Use a square to check the fit for accuracy.

Welding Procedure:

1. Tack weld the branch pipe to the header pipe.

2. Lower your helmet and say "Cover." Strike the arc and lay the bead.

3. Properly tie beads together when changing electrodes or positions.

4. Lay additional beads if necessary.

5. Clean and examine the weld. Safety goggles must be worn when chipping slag from the weld.

Demonstration Sheet 8.2: Laying Out Angles

Objective: At the completion of this demonstration, the student will be prepared to begin the job sheet on laying out an angle.

Tools and Equipment Needed:

1. Sliding T-bevel
2. Saw horse
3. Combination square
4. Soapstone

Materials Needed:

1. Black pipe - size to be determined by instructor
2. Two pieces of scrap lumber (optional)
3. Bucket of water

Procedure:

1. Find a level spot in the floor for the demonstration.

2. Set the sliding T-bevel to the desired angle. (This can be accomplished by using a combination square, carpenter's square, protractor, or the miter gauge on the table saw.)

3. Place the sliding T-bevel on the top of the saw horse and the bucket of water on the floor next to the saw horse.

4. Place the pipe on the blade of the sliding T-bevel and lower the end of the pipe to be cut into the bucket.

   NOTE: Allow the water to cover only the end of the pipe.

5. Remove the pipe from the water and mark the water line with a piece of soapstone.

6. Cut the pipe along the soapstone mark to achieve the desired angle.

   NOTE: It will often be difficult to hold the correct angle on the sliding T-bevel due to the weight of the pipe. If this is the case, transfer the angle to a piece of lumber. Cut the lumber and use it to hold the pipe in position. Best results are often obtained by cutting two pieces of lumber to a compound angle and nailing or gluing them together. This procedure produces a V-groove which prevents the pipe from rolling.

Demonstration Sheet 8.3: Closing the End of Pipe - Orange-Peel Plug

Objective: At the completion of this demonstration, the student should be prepared to begin the job sheet on closing the end of pipe.

Tools and Equipment Needed:

1. Piece of string
2. Soapstone
3. Hammer
4. Oxy-fuel torch
5. Inside calipers
6. AC or AC/DC arc welder
7. Wire brush
8. Chipping hammer
9. Helmet*
10. Leather gloves
11. Safety goggles*
12. Grinder
13. Welding goggles

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6011 electrode - 1/8 inch

Preweldlng Procedure:

1. Determine the circumference of the pipe using a piece of string.
2. Divide the length of the string into an uneven number of sections (e.g., 7, 9, etc.).
3. Mark the end of the pipe to match the sections on the string.
4. Determine the inside diameter of the pipe using the inside calipers.
5. Mark the line to be cut with soapstone.

Welding Procedure:

1. With welding goggles in place, cut the soapstone lines with an oxy-fuel torch.
2. Hammer each section toward the middle until they meet in the center. Lower your helmet and say "Cover" when tack welding the sections in place.
3. Join the ends together by welding on alternate sides of the pipe.
4. Smooth the end of the plug by grinding. Wear safety goggles and face shield when grinding.

Demonstration Sheet 8.4: Butt Joint - Repositioned

Objective: At the completion of this demonstration, the student will be able to begin the job sheet for welding butt joints in pipe that can be repositioned.

Tools and Equipment Needed:

1. AC or AC/DC welder
2. Chipping hammer
3. Helmet*
4. Pliers
5. Leather gloves
6. Safety goggles*
7. Grinder

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by the instructor
2. E6010 or E6011 electrodes

Prewelding Procedure:

1. Remove all dirt, rust, grease, and foreign material from the pipe.

2. Bevel the edges if necessary. Safety goggles and a face shield must be worn when grinding.

Welding Procedure:

1. Lower your helmet and say "Cover" before striking the arc. Tack weld the pipes together and check for proper alignment.

2. Position yourself at a 90 degree angle.

3. Strike the arc at the 3 o'clock position. Carry the arc down to the 4 o'clock position and allow a keyhole to form.

4. Manipulate the electrode with a whipping motion. Keep the electrode 5 to 15 degrees below the axis of the weld.

5. Continue welding from the 4 o'clock position to the 1 o'clock position.

6. Turn the pipe toward you one-quarter turn and weld the 1 to 10 o'clock section using the same method outline in step 4.

7. Continue turning and welding the pipe in this manner until the weld is complete.

NOTE: Start each bead segment slightly below the crater at the end of the previous segment. This will help tie each of the segments together.

8. Clean the bead; run filler and cover passes if necessary. Safety goggles must be worn while chipping slag from the weld.

Demonstration Sheet 8.5: Butt Joints - Not Repositioned

Objective: At the completion of this demonstration, the student will be able to begin the job sheet for welding butt joints that cannot be repositioned.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer
8. Soapstone
9. Grinder

*CAUTION: All students observing this demonstration must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 - 1/8 inch

Prewelding Procedure:

1. Clean all rust, dirt, grease, and other foreign materials from the surface of the pipe.

2. Bevel the edges of the pipe if the wall thickness exceeds 1/8 inch. Safety goggles and a face shield must be worn while using the grinder.

Welding Procedure:

VERTICAL-DOWN METHOD

1. Lower your helmet and say "Cover" before striking the arc. Tack weld the pipes together and check for proper alignment.

2. Assume a comfortable position which will allow for access to the pipe.

3. Strike the arc between the 11 and 12 o'clock positions and weld to the 6 o'clock position. Maintain a short arc length, a 90 degree work angle, and a 10 to 25 degree travel angle.

4. Travel fast enough to keep the electrode in the leading edge of the puddle. If slag runs in from the puddle, break the arc, clean the bead, and restart. This will help prevent slag inclusions.

5. Run the vertical down pass on the other side in the same manner.

6. Clean the bead; run filler and cover passes as necessary. Safety goggles must be worn when chipping slag from the weld.

VERTICAL-UP METHOD

1. Lower your helmet and say "Cover." Tack weld the pipes together and check for proper alignment.

2. Hold a 90 degree work angle and a 5 to 10 degree push angle.

3. Strike the arc and quickly develop a keyhole.

4. Using a slight whipping motion, weld from the 3 o'clock position to the 12 o'clock position. Be sure to maintain the 5 to 10 degree push angle.

5. Restart the arc at the 6 o'clock position, form a keyhole, and weld to the 9 o'clock position.

   NOTE: Start at the heel of each crater and momentarily hold a long arc in order to tie each bead segment together.

6. Restart the arc, form keyhole, and weld from the 6 o'clock position to the 3 o'clock position.

7. Restart the arc, form a keyhole, and weld from the 9 o'clock to the 12 o'clock position.

8. Clean the bead; run filler and cover passes as necessary. Safety goggles must be worn when chipping slag from the weld.

Job Sheet 8.1: Pipe Welding T-joints

Objective: At the completion of this job sheet, the student will be able to lay out and weld T-joints in pipe.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Safety goggles*
5. Pliers
6. Wire brush
7. Chipping hammer
8. Soapstone
9. Grinder

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed when in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 electrodes - 1/8 inch

Prewelding Procedure:

FLATTEN END METHOD

1. Cut two pieces of black pipe to the desired length.

2. Determine which is the header pipe and which is the branch pipe. (See Figure 8.1.)

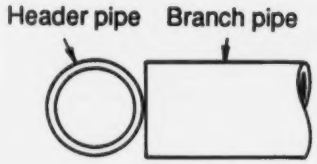


Figure 8.1

3. One end of the branch pipe should be flattened. This may be accomplished by striking the end of the pipe with a sledgehammer while the metal is cold. The branch pipe should only be flattened enough to provide a good fit. Over-flattening will weaken the pipe. (See Figure 8.2.) Safety goggles must be worn when flattening the pipe.

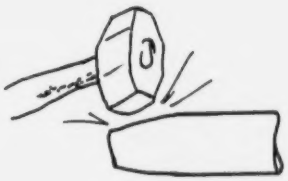


Figure 8.2

4. The end of the branch pipe to be welded should be ground to remove dirt, grease, and rust from the pipe. To increase penetration, the edges should be beveled if the wall thickness of the pipe exceeds 1/8 inch.

5. Position the branch and header pipes in the flat position on the welding table with the flat end of the branch pipe butted up against the header pipe. (See Figure 8.3.)

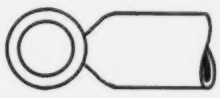


Figure 8.3

6. Use a square to check the joint for accuracy. If the joint is not square it may need to be ground for the proper fit.

7. Set amperage according to the thickness of the pipe. A range of 120 to 150 amps is recommended.

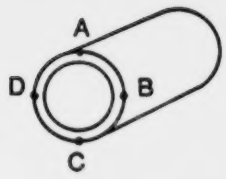


Figure 8.4

CUT AND FIT METHOD

1. Divide the circumference of the branch pipe into four equal parts. Mark each point at the end of the pipe with a center punch. (See Figure 8.4.)

2. Place the branch pipe on the header pipe. Place points A and C on the imaginary center line of the header pipe. Measure the gap distance from point B or D to the branch pipe. (See Figure 8.5.)

3. Use a ruler and marking device to move points A and C from the end of the pipe to a distance equal to the gap measured in step 2.

4. Use soapstone to connect points A, B, C, and D with arcing lines. (See Figure 8.6.)

5. With safety goggles in place, cut along the soapstone line with an oxy-fuel torch.

6. If necessary, a disc grinder can be used to dress the cut to provide a better fit. Safety goggles must be worn.

7. With safety goggles in place, bevel the edges of the branch pipe if wall thickness exceeds 1/8 inch.

8. Use a square to place the branch and header pipes in proper alignment and prepare to tack weld the pipes in position. (See Figure 8.7.)

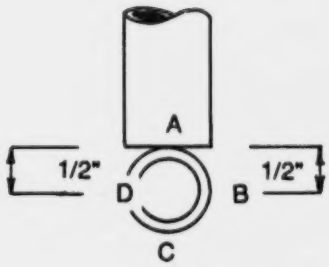


Figure 8.5

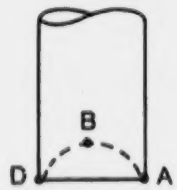


Figure 8.6

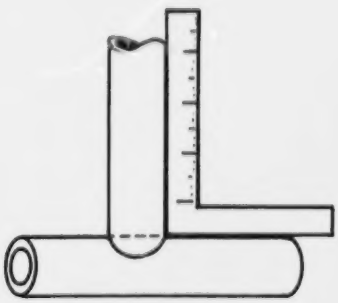


Figure 8.7

Welding Procedure:

1. Lower your helmet and say "Cover" before striking an arc. Tack weld the branch pipe to the header pipe. Four tack welds should be made opposite each other and in rapid succession to counteract contraction forces which result from the heat of the welding process.

2. Strike an arc to begin the weld. The arc should be held as close to the joint as possible to insure proper penetration. The electrode should be held at a 10 to 15 degree angle in the direction of travel. Use a weaving motion to deposit the bead. Heat should be concentrated on the heavier part of the metal to avoid burnthrough. (See Figure 8.8.)

3. Several beads will need to be made since you will have to break the arc several times to change the position of the

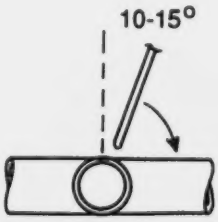


Figure 8.8

pipe. To properly tie the beads together, you should start about 1/2 inch into the end of the previous bead in order to fill the crater left by the previous bead. (See Figure 8.9.)

4. If the wall thickness of the pipe exceeds 1/8 inch, additional passes may be needed for a strong weld.

5. Clean the weld using a chipping hammer and wire brush. Safety goggles must be worn when chipping slag from the weld.

6. Examine the weld and turn it in to the instructor for grading.

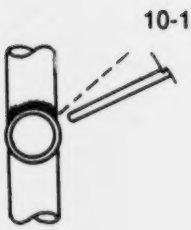


Figure 8.9

Job Sheet 8.2: Laying Out Angles

Objective: At the completion of this job sheet, the student will be able to lay out an angle on pipe.

Tools and Equipment Needed:

1. Sliding T-bevel
2. Saw horse
3. Combination square
4. Soapstone

Materials Needed:

1. Black pipe - size to be determined by instructor
2. Piece of scrap lumber (optional)
3. Bucket of water

Welding Procedure:

1. Find a place in the shop where the floor is level.

2. Secure a sliding T-bevel, a saw horse or other flat raised object, and a bucket of water.

3. Set the sliding T-bevel to the desired angle. This can be accomplished by using a combination square, a carpenter's square, a protractor, or the miter gauge on the table saw.

4. Place the sliding T-bevel on the saw horse and the bucket of water on the floor next to the saw horse.

5. Place the pipe on the blade of the sliding T-bevel and lower the end of the pipe to be cut into the bucket of water. (See Figure 8.1.)

   NOTE: Only allow the water to cover the end of the pipe.

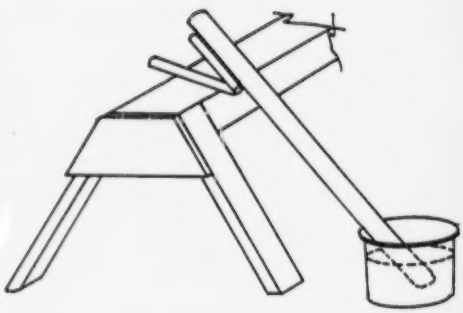


Figure 8.1

6. Remove the pipe from the water and use a soapstone to quickly mark around the water line, which will have formed on the pipe. The pipe will be cut along the mark.

   NOTE: It will often be difficult to hold the correct angle on the sliding T-bevel due to the weight of the pipe. If this is the case, transfer the angle to a piece of scrap lumber. Cut the lumber and use it to hold the pipe in position. (See Figure 8.2.) Best results are often obtained by cutting two pieces of lumber to a compound angle and nailing or gluing them together. This procedure provides a V-groove which prevents the pipe from rolling. A piece of angle iron will also work well.

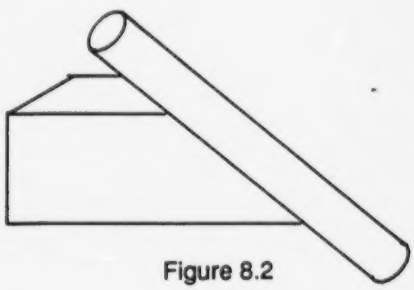


Figure 8.2

Job Sheet 8.3: Closing the End of Pipe - Orange-Peel Plug

Objective: At the completion of this job sheet, the student will be able to close the end of a pipe using the orange-peel plug method.

Tools and Equipment Needed:

1. Piece of string
2. Soapstone
3. Hammer
4. Oxy-fuel torch
5. Inside calipers
6. AC or AC/DC arc welder
7. Wire brush
8. Chipping hammer
9. Helmet*
10. Leather gloves
11. Grinder
12. Safety goggles*
13. Welding goggles

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 electrodes - 1/8 inch

Prewelding Procedures:

1. Using the piece of string, determine the circumference of the pipe.

2. Divide the length of the string into an uneven number of sections (e.g., 7, 9, etc.).

3. Mark the end of the pipe to match the sections of the string. Remember, there should be an uneven number of sections. (See Figure 8.1.)

4. Determine the inside diameter of the pipe by using the inside calipers.

5. At the point between each mark made in step 3, a slightly curved line equal to the inside diameter should be made with soapstone down the length of the pipe equal to the inside diameter. (See Figure 8.2.)

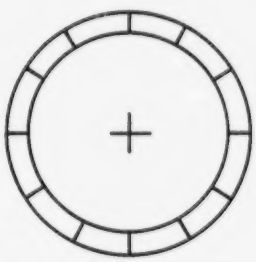


Figure 8.1

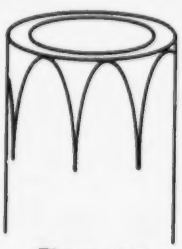


Figure 8.2

Welding Procedure:

1. Cut along the soapstone marks with an oxy-fuel torch. (See Figure 8.3.) Welding goggles must be worn while cutting.

2. Hammer each section toward the middle until they meet in the middle. With helmet in place, tack weld the sections in place.

3. Join the ends together by welding on alternate sides of the pipe. (See Figure 8.4.)

4. Smooth the end of the plug by grinding or peening. Safety goggles and a face shield must be worn while grinding.

5. Examine the welds and turn in to instructor for grading.

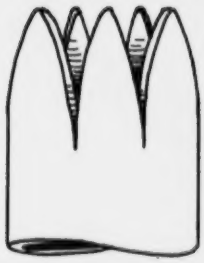


Figure 8.3

Figure 8.4

Job Sheet 8.4: Butt Joint - Repositioned

Objective: At the completion of this job sheet, the student will be able to weld a butt joint in pipe that can be repositioned.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Helmet*
3. Leather gloves
4. Chipping hammer
5. Pliers
6. Safety goggles*
7. Grinder

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 electrodes - 1/8 inch

Prewelding Procedure:

1. Remove all dirt, rust, grease, and other foreign material from the end of the pipe to be welded.

2. If pipe is greater than 1/8-inch thick, bevel the end before welding to obtain better penetration. Safety goggles and a face shield must be worn while grinding.

Welding procedure:

1. Lower your helmet and say "Cover" before striking the arc. Tack weld the pipes together and chip the slag from the tack welds. Check pipes for proper alignment. Position the pipe in the flat position.

2. Position yourself at a 90 degree angle to the joint.

3. Strike the arc at the 3 o'clock position. Carry the arc down to the 4 o'clock position and allow a keyhole to form.

4. Manipulate electrode with a slight whipping motion. Keep the electrode 5 to 15 degrees below the axis of the weld. (See Figure 8.1.)

5. Lay a bead from the 4 o'clock position to the 1 o'clock position. (See Figure 8.1.)

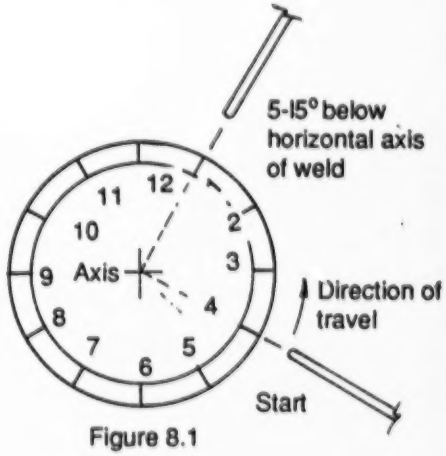


Figure 8.1

6. Turn the pipe toward you one-quarter turn and weld the 1 to 10 o'clock section using the same method outlined in step 4.

7. Continue turning and welding in this manner until the weld is complete. (See Figure 8.2.)

8. Clean the bead and run filler and cover passes as necessary.

9. Examine the weld for accuracy and turn it in to the instructor for grading.

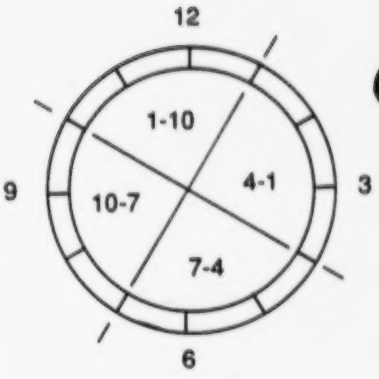


Figure 8.2

Job Sheet 8.5: Butt Joints - Not Repositioned

Objective: At the completion of this job sheet, the student will be able to weld a vertical butt joint and a horizontal butt joint in pipe that cannot be repositioned.

Tools and Equipment Needed:

1. AC or AC/DC arc welder
2. Pliers
3. Chipping hammer
4. Leather gloves
5. Wire brush
6. Safety goggles*
7. Helmet*
8. Soapstone
9. Grinder

*CAUTION: All students performing this procedure must wear proper eye protection. Safety precautions must be observed while in the shop area.

Materials Needed:

1. Black pipe - size to be determined by instructor
2. E6010 or E6011 electrodes - 1/8 inch

Prewelding Procedure:

1. Clean all dirt, rust, grease, and other foreign materials from the pipe to be welded.

2. Bevel the edges of pipe with a wall thickness of greater than 1/8 inch. Safety goggles and a face shield must be worn when grinding.

Welding Procedure:

Figure 8.1

VERTICAL-DOWN METHOD

1. Lower the helmet and say "Cover" before striking the arc. Tack weld the pipes together and check for proper alignment. (See Figure 8.1.)

2. Assume a comfortable position which will allow access to the pipe.

3. Strike the arc at the 11:30 position and weld to the 6 o'clock position. Maintain a short arc length, a 90 degree work angle and a 10 to 25 degree travel angle. (See Figure 8.2.)

4. Travel just fast enough to keep the electrode in the leading edge of the puddle. If slag runs in front of the puddle,

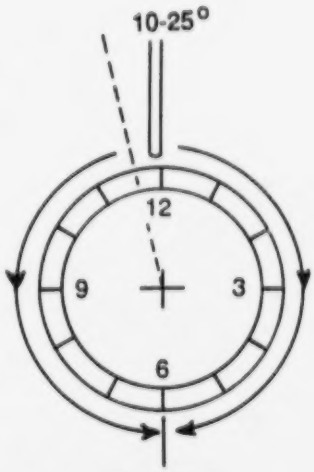


Figure 8.2

break the arc, clean the bead to prevent slag inclusion, and restart the bead.

5. Run the vertical-down pass on the other side in the same manner. Take care to tie the ends of both beads together.

6. Clean the bead and run filler and cover passes if necessary.

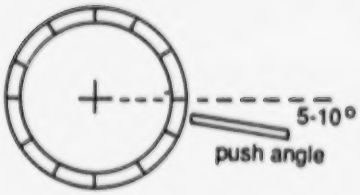


Figure 8.3

VERTICAL-UP METHOD

1. Lower the helmet and say "Cover" before striking the arc. Tack weld the pipes together and check for proper alignment.

2. Hold a 90 degree work angle and a 5 to 10 degree push angle. (See Figure 8.3.)

3. Strike the arc and quickly develop a keyhole.

4. Use a slight whipping motion and weld form the 3 o'clock position to the 12 o'clock position. Be sure to maintain the 5 to 10 degree push angle. (See Figure 8.4.)

5. Restart the arc at the 6 o'clock position, form a keyhole, and weld to the 9 o'clock position. Start at the heel of the crater and momentarily hold a long arc in order to tie each bead segment together.

6. Restart the arc, form a keyhole, and weld from the 6 o'clock position to the 3 o'clock position.

7. Restart the arc, form the keyhole, and weld from the 9 o'clock to the 12 o'clock position.

8. Clean the bead and run filler and cover passes as necessary.

9. Examine the weld and turn it in to the instructor for grading.

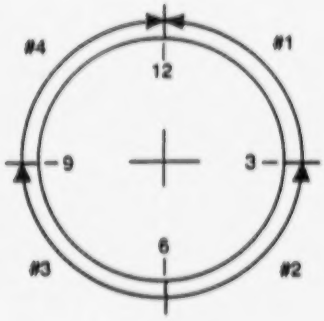


Figure 8.4

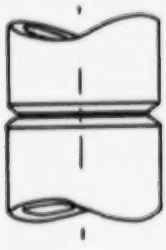


Figure 8.5

HORIZONTAL METHOD

1. Lower your helmet and say "Cover" before striking the arc. Tack weld the pipes together and check for proper alignment.

2. The axis of the pipe will be in the vertical position, resulting in the weld joint being on a horizontal plane. (See Figure 8.5.)

3. Angle the electrode 5 to 10 degrees below the weld joint. (See Figure 8.6.)

4. Maintain a travel angle of 5 to 10 degrees from the axis of the pipe, as shown in Figure 8.7.

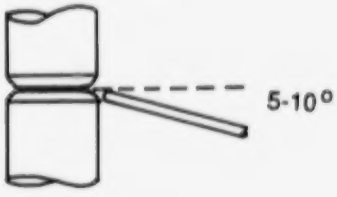


Figure 8.6

5. Strike the arc and start a keyhole. Use a whipping motion to control the weld puddle. (See Figure 8.8.)

6. Continue welding around the joint while maintaining the proper work angle and travel angle.

7. If the upper pipe melts excessively, decrease the electrode angle so that the welding heat will be concentrated more on the lower pipe.

8. It will be necessary to stop and restart the bead several times. Restart the beads in the heel of the previous crater and momentarily hold a long arc to preheat the crater.

9. Clean the bead and run filler and cover passes as necessary.

10. Examine the weld and turn it in to the instructor for grading.

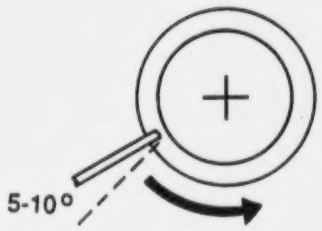


Figure 8.7

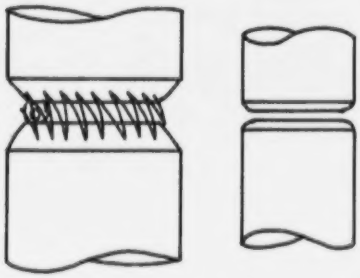


Figure 8.8

AGRICULTURAL CONSTRUCTION (Volume I)

UNIT VI - PROJECT CONSTRUCTION

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OBJECTIVES

1. The student will be able to list the safety procedures for project construction.

2. The student will be able to select and design a project plan.

3. The student will be able to develop a bill of materials and estimate the cost of a project from a working drawing or plan.

4. The student will be able to list tools needed to complete a project and list safety precautions for each tool.

5. The student will be able to determine a time frame for completion of a project.

6. At the completion of this lesson, the student will be able to interpret a project plan using skills acquired in previous lessons.

7. The student will be able to lay out and prepare materials for cutting.

8. The student will be able to determine proper hitching and balancing in construction design.

9. The student will be able to determine if the construction design meets all legal specifications of the state.

10. The student will be able to identify and correct project defects by approved methods.

11. The student will be able to assemble his or her project to the best of his or her abilities.

12. The student will be able to describe why a project should have a finish.

13. The student will be able to determine actual cost of materials and labor for the project.

14. The student will be able to safely use all tools needed for completing his or her individual project.

NOTE: Percent of accuracy should be set by instructors to reflect passing grades within their school system.

COMPETENCIES

1. List the safety procedures for project construction.

2. Select and design a project plan.

3. Develop a bill of materials and a projected cost list.

4. List tools needed to complete a project and list related safety precautions.

5. Determine the time frame for completion of a project.

6. Interpret a project construction plan.

7. Lay out and prepare materials for cutting.

8. Determine construction design for proper hitching and balancing.

9. Determine construction design for legal specifications: width, length, weight, etc.

10. Identify and correct project defects by approved methods.

11. Perform assembly procedures.

12. Describe why a project should have a finish.

13. Determine actual cost of materials and labor for project.

14. Use hand and power tools in completing a project.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Present the following situation to students and ask the following questions. Jimmy, a local farmer, needs a large round bale feeder to winter feed his beef cattle. He visits the local farm supply store and discovers that he will have to pay $130.00 for the feeder that fits his needs. He decides to build it himself to save money. What should Jimmy consider before he begins to build the bale feeder? How can he determine how much it will cost him to make the bale feeder? Does Jimmy have the skills necessary to build the feeder?

2. Show students a project that has been constructed in the shop. To illustrate the amount of time and planning involved in the project, ask students to list tools needed and processes performed to complete the project. Point out items that have been overlooked.

3. Ask students to identify an item for the SAE program that could be constructed in the agricultural education shop. List each item on the board. When all students have had an opportunity to contribute, ask the class to determine which items can be built in the shop. If the class decides that an item cannot be constructed in the shop, discuss why not.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.

2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background acquired from earlier units.

3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

   a) Agricultural Construction (Student Handouts). Vol. 1. University of Missouri-Columbia: Instructional Materials Laboratory, 1989.

2. Teacher References

   a) Arc Welded Projects. Cleveland: James F. Lincoln Arc Welding Foundation, 1978.

   b) Arc Welded Projects Vol II. Cleveland: James F. Lincoln Arc Welding Foundation, 1978

   c) Hamilton, W.H.; A.R. Mann; F. Bear. Planning Project Construction. St. Paul, MN: Hobar Publications, 1981.

   d) Ludwig; McCarthy; Repe. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Company, 1969.

   e) Missouri Highway Patrol, Commercial Motor Vehicle Division, 1510 E. Elm, Jefferson City, MO 65101.

f) Modern Welded Structures: Selections from Volume I and II. Cleveland: James F Lincoln Arc Welding Foundation, 1965.

g) Resource Guide for Performance-Based Welding Instruction. College Park, MD: University of Maryland, 1977.

h) "Selecting and Using a Fire Extinguisher." Agricultural Guide #1906. University Extension, University of Missouri-Columbia.

i) Wagner, W.H.; C.E. Kicklighter. Modern Woodworking, Tools Materials, and Processes. South Holland, IL: Goodheart-Willcox Company Inc., 1986.

j) Welding Projects for School Shops. Troy, OH: Hobart Welding School.

3. Shop Project Plans

a) Ag. Mechanics Single Sheet Plans. Columbia, MO; University of Missouri-Columbia: Instructional Materials Laboratory.

b) Ag. Mechanics Plans. Columbia, MO; University of Missouri-Columbia: Instructional Materials Laboratory.
   1) How to Build a Wagon Chassis
   2) How to Build a Combination Trailer-Loading Chute
   3) How to Build a Scraper Blade
   4) How to Build a Tandem Trailer
   5) How to Build a Tractor Carry-all
   6) How to Build an Auger Unloading Wagon
   7) How to Build an All-purpose Wagon Box
   8) How to Build a Heavy Duty Tractor Blade with Equipped for Hydraulic Cylinders
   9) How to Build a Heavy Duty Combination Carry-all or Bale Mover
   10) How to Build a Heavy Duty Truck Bumper
   11) How To Build a Heavy Duty Farm Utility Trailer
   12) How to Build a Pickup Mounted Large Bale Mover
   13) How to Build a Big Round Bale Mover
   14) How to Build a Pasture Renovator
   15) How to Build an Oxy-Acetylene Welding Table
   16) How to Build an Engine Stand
   17) How to Build a Calf Creep Feeder
   18) How to Build Salt & Mineral Feeder
   19) How to Build a Cattle Self Latching Headgate
   20) How to Build a Cattle Siding Stanchion Headgate
   21) How to Build a Livestock Gate
   22) How to Build a Gooseneck Trailer
   23) How to Build a Hydraulic Livestock Trailer
   24) How to Build a Pickup Rack (Wood)
   25) FFA-BOAC Small Shop Project
   26) How to Build a Hydraulic Log Splitter
   27) How to Build a Barrel Barbecue
   28) How to Build a Plywood Utility Building

c) Agriculture Mechanics Shop Project Plans. Oklahoma; Available through the Instructional Materials Laboratory.

AGRICULTURAL CONSTRUCTION

UNIT VI - PROJECT CONSTRUCTION

MAJOR COMPETENCY PROFILE

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect employability readiness rather than the grades given in class.

Rating Scale:

3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N

Project Construction

*1. List the safety procedures for project construction.

2. Select and design a project plan.

3. List tools needed to complete project and list safety precautions.

4. Develop a bill of materials and projected cost list.

5. Determine a time frame for completion of a project.

6. Interpret the project construction plan.

7. Lay out and prepare materials for cutting.

8. Determine construction design for proper hitching and balancing.

9. Determine construction design for legal specification: width, length, weight, etc.

AGRICULTURAL CONSTRUCTION

UNIT VI - PROJECT CONSTRUCTION cont.

MAJOR COMPETENCY PROFILE

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect employability readiness rather than the grades given in class.

Rating Scale:

3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N

Project Construction cont.

10. Identify and correct project defects by approved methods.
11. Perform assembly procedures.
12. Describe why a project should have a finish.
13. Determine actual cost of materials and labor for project.
14. Hand and power tools used in completing this project.

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____
g. _____

AGRICULTURAL CONSTRUCTION

UNIT VI - PROJECT CONSTRUCTION cont.

MAJOR COMPETENCY PROFILE

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N **No Exposure** - no experience or knowledge in this area

3	2	1	N

Project Construction cont.

14. Hand and power tools used in completing this project. (cont.)
    i. _____
    j. _____
    k. _____
    l. _____
    m. _____
    n. _____
    o. _____

Other (specify)

_____

_____

_____

***NOTE:** All competencies involving safety require a Number 3 Rating.

AGRICULTURAL CONSTRUCTION
Unit VI: Project Construction

CLASS/SECTION: _____

STUDENTS:

	*1. List the safety procedures for project construction.	2. Select and design a project plan.	3. List tools needed to complete project and list safety precautions.	4. Develop a bill of materials and projected cost list.	5. Determine a time frame for completion of a project.	6. Interpret the project construction plan.	7. Lay out and prepare materials for cutting.	8. Determine construction design for proper hitching and balancing.	9. Determine construction design for legal specification; width, length, weight, etc.	10. Identify and correct project defects by approved methods.	11. Perform assembly procedures.	12. Describe why a project should have a finish.	13. Determine actual cost of materials and labor for project.	14. Hand and power tools used in completing this project.

UNIT VI - PROJECT CONSTRUCTION

Lesson 1: Safety Procedures for Project Construction

Objective: The student will be able to list the safety procedures for project construction.

Study Questions

1. What personal protective clothing and gear are used for working safely in the shop?
2. What are some safety considerations concerning the physical parts of the shop or building?
3. What safety aspects should be considered before work is started?
4. What safety aspects should be considered when students are actively at work in the shop?
5. How are fires classified and controlled?

References

1. "Selecting and Using a Fire Extinguisher." Agricultural Guide #1906. University Extension, University of Missouri-Columbia.
2. Handout
   a) HO 1.1: Project Construction Safety

UNIT VI - PROJECT CONSTRUCTION

Lesson 1: Safety Procedures for Project Construction

TEACHING PROCEDURES

A. Introduction

Introduce the unit on project construction. Explain to students how the unit is organized and how it will aid in constructing projects.

B. Motivation

Begin collecting photographs and plans for student projects. Show students what has been accomplished in project construction by other students or other schools. Talk about limiting factors in project construction and how often these limiting factors exist only in the individual's mind. Encourage creativity and thought. Show students examples of State Fair projects and awards won through the Lincoln Arc Welding Awards program.

C. Assignment

D. Supervised study

E. Discussion

1. Safety is more than lists of rules or regulations. It is a way of thinking and acting. It is of utmost importance that each student work in a safe manner and under safe conditions. Ask students to name safety gear and clothing that should be worn for protection.

   What personal protective clothing and gear are used for working safely in the shop?

   a) Eye protection
      1) Safety glasses are required as minimum protection in any shop activity.
      2) An arc helmet is required when arc welding.
      3) Acetylene goggles are required when performing oxyacetylene activities.
   b) Proper clothing
      1) Wear tight-fitting clothing.
      2) Clothing should be made of natural fibers, such as cotton or wool, or made of fabric that is fire retardant.
      3) Button long sleeve cuffs.
      4) Wear work shoes or boots at least six inches high.
      5) Wear gauntlet-type gloves in welding and in handling sharp materials.
      6) Keep hands free of grease or oil.
      7) Avoid wearing jewelry.
      8) A hair guard is required for long hair.
      9) Use respirators when required in such activities as painting or sandblasting.
      10) Use respirators when welding in a confined area (such as a feed wagon)

2. The conditions of the shop directly influence the safety of the workers. Ask students to list areas of the shop that are possible danger zones.

What are some safety considerations concerning the physical parts of the shop or building?

a) Housekeeping
   1) Properly store materials and supplies in designated areas.
   2) Keep machines, equipment, and the areas around them clear.
   3) Keep working areas such as benches and floors clean and orderly.
   4) Keep traffic areas clear.
   5) Hand and power tools should be stored correctly.
b) Lighting
   1) Lighting should be sufficient and well-placed.
   2) Use safe lighting structures.
c) Ventilation - Fresh air should be adequate and circulating.

3. Safety is important even before work begins. Have the class list reasons for proper planning of projects. Is safety included in their reasoning?

What safety aspects should be considered before work is started?

a) Always plan work before starting. Think it through.
b) Consider tools, equipment, and materials that will be needed.
c) Secure approval from the instructor for all work to be done in the shop.
d) Be open to suggestions for the easiest and safest ways to accomplish tasks.

4. Some students may not be used to working with others. The aspects of safety change somewhat when there is more than one individual working in an area of the shop.

What safety aspects should be considered when students are actively at work in the shop?

a) Work at a speed that is safe and sure.
   1) Safe skills should be developed before speed.
   2) A steady, unhurried pace is safest and produces the best work.
b) Consider others in the shop.
   1) Be thoughtful and helpful toward other students.
   2) Be sure the work of one does not endanger someone else.
   3) Caution others if they are violating a safety rule.
c) Use equipment properly.
d) Select and use tools properly.
e) Use proper procedure when lifting heavy objects.
   1) Protect back muscles when lifting. Lift with arm and leg muscles.
   2) Do not be afraid to ask for help.
   3) Ask for help when handling long pieces of stock, even if they are not heavy.

5. Fire is always a potential danger in any agricultural shop. Ask students to list possible causes of fire in a shop. How do fires differ? Inspect the different fire extinguishers located in the shop and read the instructions. Distribute copies of MU Guide #1906.

How are fires classified and controlled?

a) Class-A fires

1) These are fires involving paper, wood, rubber, cloth, and other ordinary materials that produce ash when burned.
2) Class-A extinguishers are water-filled extinguishers.

b) Class-B fires
1) These are fires involving flammable liquids and gases, grease, and oil.
2) Class-B extinguishers use dry chemical, multipurpose, or foam materials.

c) Class-C fires
1) These are fires that are electrical in nature.
2) Class-C extinguishers will fight fire in live electrical equipment.
3) Cut the current promptly because no extinguisher will permanently put out an electrical fire which is being constantly fed more current.
4) Class-C symbol will always be found on multi-purpose, dry chemical, and carbon dioxide extinguishers; it is never found on water or foam extinguishers.

d) Class-D fires
1) These are fires that occur with combustible metals.
2) Specialized techniques, agents, and equipment are used to control Class-D fires.
3) Suitable extinguishers for Class D fires are identified with a five-point star with a letter "D" printed within.

e) Combination - Single extinguishers are available to successfully fight any fire. They may be classified as a combination type extinguisher such as 'ABC'.

NOTE: Instructors and students need to be aware of other extinguishing means in a fire emergency. A 100 percent wool fire blanket is a necessary item in many agricultural education laboratories. It can be used to aid victims with burning clothing (by smothering flames). Typically, fire blankets are stored in a special, well-marked, and accessible compartment within the laboratory.

Do not let a person with burning clothing run. Furthermore, since melted synthetic clothing material can cause serious skin damage if extinguished by rolling or using a blanket, water is thought to be the most effective method in extinguishing burning clothing. Work clothing (overalls, aprons, etc.) worn in shops/laboratories with significant fire hazards should be 100 percent cotton fabric or otherwise fire resistant. Synthetic fabrics or partially synthetic fabrics should not be worn in the shop.

F. Other activities

1. Inspect the shop for safety.

2. Invite the local fire chief to speak to the class about fire safety and control.

3. Construct a safety bulletin board for the school.

4. Display safety equipment needed for various shop activities such as welding, cutting, painting, and woodworking.

5. Show safety films from your local welding supplies distributor.

G. Conclusion

Safety should be the No. 1 rule for every person building any project in every work area.

H. Competency

List the safety procedures for project construction.

I. Answers to Evaluation

1. c
2. c
3. a
4. a
5. e
6. d

UNIT VI - PROJECT CONSTRUCTION Name _____

Lesson 1: Safety Procedures for Project Construction Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which one of the following clothing types is considered unsafe in project construction-handling, cutting, and welding?

   a. 6" high work boots
   b. Long-sleeved shirts
   c. Synthetic clothing
   d. Tight-fitting clothing
   e. Cotton or wool clothing

2. Which muscles should be used to avoid injury when lifting heavy weight?

   a. Neck
   b. Back
   c. Leg
   d. Forearm
   e. Shoulder

3. Which one of the following should not be considered when working in a shop?

   a. Speed is developed before skills.
   b. A steady pace produces the best work.
   c. Caution others if they are unsafe.
   e. Be thoughtful and helpful toward others.

4. A water-filled fire extinguisher is used on a _____.

   a. Class A fire
   b. Class B fire
   c. Class C fire
   d. Class D fire
   e. Class E fire

5. The class C fire is one that involves _____.

   a. Gas or oil
   b. Chemicals
   c. Paper and wood
   d. Combustible metals
   e. Electricity

6. Fire blankets are typically stored in a(n) _____.

   a. Fire-proof cabinet
   b. Open area outside the lab
   c. Welding booth
   d. Marked compartment within the lab
   e. Tool room

Safety is more than a list of rules and regulations. It is more than the dos and don'ts of work. Safety is a way of thinking and acting.

Protective Clothing and Gear

The person in the shop or work area must be properly protected for safe working. It is the responsibility of each worker to use proper eye protection and safety gear as well as to wear proper clothing.

Eye protection - Proper eye protection is determined by the equipment to be used and the work to be accomplished. Safety glasses or goggles are required as minimum protection in any shop activity. An arc welding helmet with a No. 10 shaded lens is required when arc welding to protect the eyes from the intense ultraviolet and infrared light. Special tinted goggles with a No. 5 or No. 6 shaded lens are required when welding or cutting with oxyacetylene.

Proper clothing - The worker should wear tight-fitting clothing as any loose clothing can become entangled in a machine's moving parts. Clothing should be made of natural fabric such as cotton or wool. Synthetic fabric such as polyester is petroleum-based and melts on a person's body as it burns. For this reason, synthetic fibers should not be worn. If long sleeved shirts are worn the cuffs should be buttoned so as not to get caught in equipment.

Workers should protect their feet with boots that are at least six inches in height. Tennis shoes or low shoes do not protect the feet from hot metal or burning embers that fall from the workbench.

Gauntlet-type gloves should be worn when welding to protect the hands and forearms from burns and radiation. Gloves are also worn to protect the hands in handling sharp metal. The worker's hands should be clean and free of grease or oil.

Jewelry should be removed before work is started. Some type of hair guard is required for those individuals with long hair. When painting or sandblasting, a respirator is worn to protect the worker from inhaling unhealthy particles.

The Condition of the Shop

The condition of the shop influences the worker's safety. It is important that the shop be maintained in a neat and safe fashion.

Housekeeping - Material and supplies should be stored properly in designated areas. Machines and equipment as well as the areas around them should be kept clean. Work benches, floors, and work areas should be kept clean and orderly. Traffic areas should also be clear. All hand and power tools should be stored properly.

Lighting - Lighting in a shop or work area should be well placed and sufficiently bright. Lighting structures should be safely wired and supported.

Ventilation - Ventilation of a shop is important to the comfort and health of the worker. Fresh air should be adequate and circulate throughout the shop. Respirators should be used when welding in confined areas, such as feed wagons.

Safety Considerations Before Work

Safety should be considered even before work begins. The worker should always plan ahead for the work that is to be accomplished. Tools, equipment, and materials to be used should be considered to make sure that all safety aids are available. Approval from the instructor should be secured for any work to be performed in the shop. Each worker should be open to suggestions for the easiest and safest ways to accomplish specific tasks.

Safety Considerations During Work

Working alone is different than working with people around you. Always work at a safe and sure speed. Safe working skills should be developed before speed is developed. A steady, unhurried pace is safest and often produces the best work.

When working with others in the shop, it is only right to be thoughtful and helpful toward fellow workers. Be sure that the work of one does not endanger someone else. Caution workers who are acting in an unsafe manner, so that no one gets hurt.

All equipment should be used for the purpose it was designed for. Both hand and power tools should be used properly.

When lifting heavy objects, do not lift with your back but use your arm and leg muscles. Do not be afraid to ask for help. Ask for help in handling long pieces of stock even if they are not heavy.

UNIT VI - PROJECT CONSTRUCTION

Lesson 2: Selecting and Designing a Project Plan

Objective: The student will be able to select and design a project plan.

Study Questions

1. Why is planning crucial to project construction?
2. How will proper planning help in project construction?
3. What are the chief considerations in designing a project?
4. What questions should the student ask to determine the suitability of a project to construct?
5. Where can one find ideas for a project to construct?

References

1. Handouts
   a) HO 2.1: Project Construction Check List
   b) HO 2.2: Selecting and Designing a Project

UNIT VI - PROJECT CONSTRUCTION

Lesson 2: Selecting and Designing a Project Plan

TEACHING PROCEDURES

A. Review

Review "Material Selection and Plan Reading Interpretation" from the Agricultural Science II curriculum.

B. Motivation

The time spent in properly planning a project is never wasted. Compare past students' experiences of how planning affected their projects. Show good and poor examples of plans to the students. Let students know the instructor's expectations.

C. Assignment

D. Supervised study

E. Discussion

1. The investment of time and work in selecting and designing a useful project will be advantageous to the instructor as well as students involved. Have students define "planning" in their own words.

   Why is planning crucial to project construction?

   a) Planning involves thinking through an activity before it is performed.
   b) Planning includes the following:
      1) Project selection
      2) Project design
      3) Procedure development
      4) Cost estimation

2. Great emphasis should be placed on planning a project for construction. Ask students how planning will help them.

   How will proper planning help in project construction?

   Careful planning can save time, materials, and energy as well as ensure a good product and profitable operations for the business person.

3. Designing involves creating, inventing, searching, and developing. Some students are motivated to design their own projects, but others are completely satisfied with constructing a project from an existing plan. What should be considered when designing a project?

   What are the chief considerations in designing a project?

   a) Function
      1) Function is the use and purpose of the project.

2) Ask whether the project will serve the function for which it was designed.

b) Material
   1) Material is the stock needed to build the project.
   2) Ask whether the materials selected are appropriate, economical, and durable.

c) Method
   1) Method is the procedure to be followed.
   2) Ask whether the methods used in construction will be simple and practical.

d) Appearance
   1) Appearance is the eye appeal.
   2) Ask whether the project is proportional, balanced, and eye-pleasing.

4. In planning a project, the student generally needs to answer several questions to determine suitability of the project. HO 2.1 should be given to students for assistance with this question.

What questions should the student ask to determine the suitability of a project to construct?

a) Do I have abilities that will be developed in the completion of the project?
b) Is the project challenging but still within the range of my competencies?
c) Will I learn new abilities?
d) Will I repeat present skills?
e) Will this project provide an opportunity for creativity?
f) Am I interested and enthusiastic enough to complete this project?
g) Are adequate plans available or must I develop my own?
h) Is there an opportunity to improve the project design for my application?
i) Can the project be completed within the time available?
j) Is the cost of the project a limiting factor?
k) Have I discussed the project with my instructor?
l) Have I discussed the project with my parents?
m) Have I examined all available references?
n) Are the necessary materials available?
o) Are the tools available?

5. Some students may not know where to find project ideas. Encourage students to think and to be creative. New ideas are often hatched from old ideas. Changing existing plans may be beneficial and necessary for some students and situations. Ask students to think of possible resources for projects and plans.

Where can one find ideas for a project to construct?

a) Books
   1) Arc Welding Projects volumes I, II, and III from James F. Lincoln Arc Welding Foundation
   2) Agricultural mechanics textbooks

b) Farm magazines and agricultural college files
   1) Farm magazines
   2) Instructional Materials Laboratory of the University of Missouri-Columbia
   3) Other state universities and agricultural colleges

c) Agriculture instructor
   1) Previous students' plans
   2) Local farmers' requests

d) People
   1) Parents

2) Equipment dealers
3) Classmates
4) Local producers

e) Show and fair entries
1) Equipment shows
2) Local, county, and state fairs

NOTE: Avoid copying a patented item.

F. Other activities

1. Send for information or plans from numerous instructional agencies such as the Instructional Materials Laboratory, University of Missouri-Columbia; University of Idaho in Moscow, Idaho; James F. Lincoln Arc Welding Foundation; Hobart School of Welding; and Texas A&M.

2. Select and design a project as a class. Go through all the necessary steps of deciding what needs to be built. Plan what and how it is to be accomplished. Consider tools, equipment, materials, and time scheduling. Calculate cost.

G. Conclusion

Selecting a project is the first decision to be made by a student in agricultural construction. Much thought and consideration is required in project selection. A project to be selected should be useful, challenging, and economically feasible.

H. Competency

Select and design a project plan.

I. Answers to Evaluation

1. c
2. a
3. Answers should include five of the following:
   a. Books
   b. Farm magazines
   c. Instructional Materials Laboratory of the University of Missouri-Columbia
   d. Other state universities and agricultural colleges
   e. Agricultural instructor
   f. Parents
   g. Equipment dealers
   h. Classmates
   i. Local producers
   j. Equipment shows
   k. Local, county, and state fairs

Name _____

Lesson 2: Selecting and Designing a Project

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following would be considered first in planning a project to be constructed?

   a. Procedure development
   b. Time scheduling
   c. Project selection
   d. Material listing
   e. Cost estimation

2. The chief considerations in designing a project include _____.

   a. Function, material, method, and appearance
   b. Cost, time, and efficiency
   c. Salability, material, and color
   d. Use, abuse, and cost
   e. Construction procedure and equipment needed

Complete the following short-answer question.

3. List five resources for project ideas.

   a.

   b.

   c.

   d.

   e.

PROJECT CONSTRUCTION CHECK LIST

TYPE OF PROJECT _____

	YES	NO	
1.	_____	_____	Will the project be useful to me or my parents?
2.	_____	_____	Do I have the skills needed to construct the project?
3.	_____	_____	Will construction of the project provide new competencies?
4.	_____	_____	Can the project be constructed in the time available?
5.	_____	_____	Can I afford the cost of the project?
6.	_____	_____	Are the tools and materials available that are needed for the project?
7.	_____	_____	Have the project plans been approved by the instructor?
8.	_____	_____	Have the project plans been approved by my parents?

I have read the above statements and agree that the project described above will be acceptable as a project in the agriculture education shop.

Teacher's signature _____

Parent's signature _____

Student's signature _____

Planning in Relation to Project Construction

The time invested in properly planning a project is never wasted. Planning involves the thinking through of an activity before the activity is performed. Planning a project includes:

1. Project selection
2. Project design
3. Procedure development
4. Cost estimation

Project selection - Planning a project begins with the selection of a specific project. A project should be useful and meet the needs for which it was constructed. For example, a big bale hay feeder would not be a practical project to select for a broiler producer but would be quite useful for an expanding cow and calf operation.

Project design - If an existing plan is not available for a selected project, a design must be made. Designing a project involves drawing the plan and making necessary changes to make sure the project will be safe, strong, and useful.

Procedure development - When a drawn plan is completed, the builder is able to develop the construction procedure to complete the project. Writing down the steps will help the builder think through the construction procedure and determine what equipment should be utilized and what materials are required.

Cost estimation - Once materials are listed, the cost may be accurately calculated. The amount of time required to complete a project is helpful to the builder, the supervisor, and a prospective buyer. Time estimation of work to be performed is used to figure labor cost. If a project is to be sold, the set price must at least cover labor cost plus material cost. Time scheduling is an important aspect in staying in business.

Reasons for Proper Planning

Proper and careful planning saves time, materials, and energy. Careful planning also ensures a good quality product and a profitable operation for those in business.

Considerations When Designing a Project

The chief considerations in designing a project are function, material, method, and appearance of the project.

Function - The function of a project involves the purpose of the project and how it is to be used. A project or product should serve the purpose for which it was designed. For example, a newly constructed bookcase should have enough space between shelves to accommodate the large books that are a part of a person's library. What use is a bookcase if books cannot be placed on it?

Material - Material is the stock needed to build a project. Materials should be appropriate, economical, and durable. For example, the material used to construct a bunk feeder should be safe, long lived, economical, and durable. Some feeders are made of concrete while others are made of wood.

Method - The method of construction involves the procedure by which the project is built. The construction method should be simple and practical. For example, a utility shed is not built from the roof to the floor; fabrication begins at the base in floor layout and construction.

Appearance - Every project should be eye appealing. An eye appealing project is one that is proportional and balanced. People enjoy looking at beautiful things. A project that is unsightly is generally not used, or at least no additional ones are asked to be built.

Sources of Information

Books - There are a number of resources for project ideas. Plans and ideas for projects can be found in agricultural mechanics and industrial arts textbooks. The Lincoln Arc Welding Foundation has three volumes of arc welding projects.

Magazines and agricultural college files - Farm magazines often have ideas for useful agricultural projects. Most plans are designed by farmers. The Instructional Materials Laboratory of the University of Missouri has a number of practical plans for agricultural use. Many agricultural colleges and other state universities have a file of plans for distribution. These include the states of Idaho, Oklahoma, Texas, and Kansas.

Agriculture Instructor - Check with your instructor for project ideas. Most agriculture teachers keep a file of projects from previous students or from local farmers who have requested projects.

People around you - The old saying that "two heads are better than one" is true. The people around you may have a pool of possible project ideas. Ask your parents, equipment dealers, classmates, and local producers for project ideas.

Shows and fairs - Also check at farm equipment shows and local, county, and state fairs.

UNIT VI - PROJECT CONSTRUCTION

Lesson 3: Developing a Bill of Materials and Projected Cost List

Objective: The student will be able to develop a bill of materials and estimate the cost of a project from a working drawing or plan.

References

1. Handout

   a) HO 3.1: Carry-All Working Drawing

2. Work Sheets

   a) WS 3.1: Estimated Bill of Materials
   b) WS 3.2: Parental Permission Form for Project Material Purchase
   c) WS 3.3: Where Are Materials Obtained?

UNIT VI - PROJECT CONSTRUCTION

Lesson 3: Developing a Bill of Materials and Projected Cost List

TEACHING PROCEDURES

A. Review

Review with students the need for a project plan. Discuss ways a project plan can save time, energy, materials, and money.

B. Motivation

Making a bill of materials is a key to project construction. A bill of materials is useful because everything needed for construction is listed for the builder. Ask the students to list the pros and cons of using a bill of materials. Display a sample bill of materials.

C. Assignment

Distribute the working drawing of a tractor carry-all (HO 3.1) to students. Discuss the components of the working drawing and review how working drawings are interpreted. Distribute a blank copy of WS 3.1 so that students can estimate the cost of building the carry-all. A completed copy of the worksheet is provided as a reference for the teacher. A list of the price/unit used to complete the worksheet is also provided. The instructor may wish to supply the students with current prices from local suppliers.

Upon completion of a bill of materials and estimated cost list for the tractor carry-all, students should complete WS 3.1 for a project they plan to construct. Final estimation of cost may determine if a student is able to construct the project and if the student's parents are willing to finance the project.

WS 3.2 should be used to obtain parental permission for the student to construct the listed project and to purchase the materials for the project. Students should take the completed copies of WS 3.1 and WS 3.2 for their project home to get approval from their parents. These forms should be kept on file in the office.

An additional worksheet (WS 3.3) is provided for students to keep track of where materials for the project are obtained. Keeping a record will be helpful if additional materials need to be purchased.

D. Supervised study

E. Discussion

Help students work out problem areas in their materials list and cost estimation. If students are unable to purchase specific materials from the school, direct them to reputable dealers.

F. Other activities

1. Make a file of project plans to be constructed by the class.

2. Make a bulletin board or flow chart showing how a project is selected, designed, planned, and constructed. Use photographs and drawings of the process to tell the story from beginning to end.

3. Take pictures of each student and the student's project as a record of accomplishment. Submit noteworthy efforts to the local newspaper or display pictures on the school's main bulletin board.

G. Conclusion

Developing a bill of materials is necessary for both small and large projects. Knowing what is needed and knowing the approximate cost for the project will enable each student to weigh investment of time, skill level, and money to determine the right project.

H. Competency

Develop a bill of materials and a projected cost list.

I. Answers to Work Sheets

1. Work Sheet 3.1 - Estimated Bill of Materials

The following prices were used to determine total cost of the tractor carry-all. The instructor may wish to supply students with current prices from a local supplier.

3" channel iron - $.082/in
1/4" x 3" flat iron - $.0574/in
1/2" x 3" flat iron - $.11475/in
1/4" x 4 flat iron - $.0765/in
3/16" x 1 1/4" angle iron - $.027125/in
3/16" x 2 1/2" x 2 1/2" angle iron - $.0562917/in
7/8" x 5" hitch pins - $4.69/ea
lumber - $5.80/10 ft. board
nuts - $.04/ea
washers - $.04/ea
carriage bolts - $.17/ea

A sample bill of materials for a tractor carry-all follows.

ESTIMATED BILL OF MATERIALS WS 3.1

STUDENT NAME: SAMPLE PROJECT

PROJECT TITLE: TRACTOR CARRY-ALL

No. of Pieces	Dimensions	Stock	Part & Use	Total Length	Est. Unit Cost*	Total Cost
2	3"x 53.25"	channel iron	forks	106.5"	$4.37	$8.74
1	3"x 25"	channel iron	cross piece	25"	2.05	2.05
2	.25"x 3"x 12"	flat iron	fork channel closer	24"	.69	1.38

2	.5"x 3"x 34"	flat iron	uprights	68"	3.90	7.80
2	.5"x 3"x 29"	flat iron	uprights	58"	2.22	4.44
1	.25"x 4"x 26"	flat iron	reinforcing plate	26"	1.99	1.99
1	.5"x 3"x 2"	flat iron	spacer	2"	.23	.23
2	.1875"x 1.25"x 1.25"x 10"	angle iron	fork part	20"	.27	.54
2	.1875"x 1.25"x 1.25"x 22"	angle iron	upright	44"	.60	1.20
1	.1875"x 2.5"x 2.5"x 60"	angle iron	heel	60"	3.38	3.38
14	2"x 6"x 60"	7-CCA lumber 2"x 6"x 10'	floor	70'	5.80	40.60
54	.375"x 2.5"	carriage bolts	fastener		.17	9.18
54	.375"	washers			.04	2.16
54	.375"	nuts			.04	2.16
2	.875"x 5"	hitch pins			4.69	9.38

Estimated Total Cost_____$95.23

Material Deposit_____

Wastage: ____0__ percent

NOTE: *Estimated Unit Cost is figured on the actual length needed for the project. You should check with your local steel dealer for minimum purchase length or cutting costs and be sure to figure this in when estimating a bill of materials.

**Because of figuring for exact lengths listed, there is 0% waste on this project.

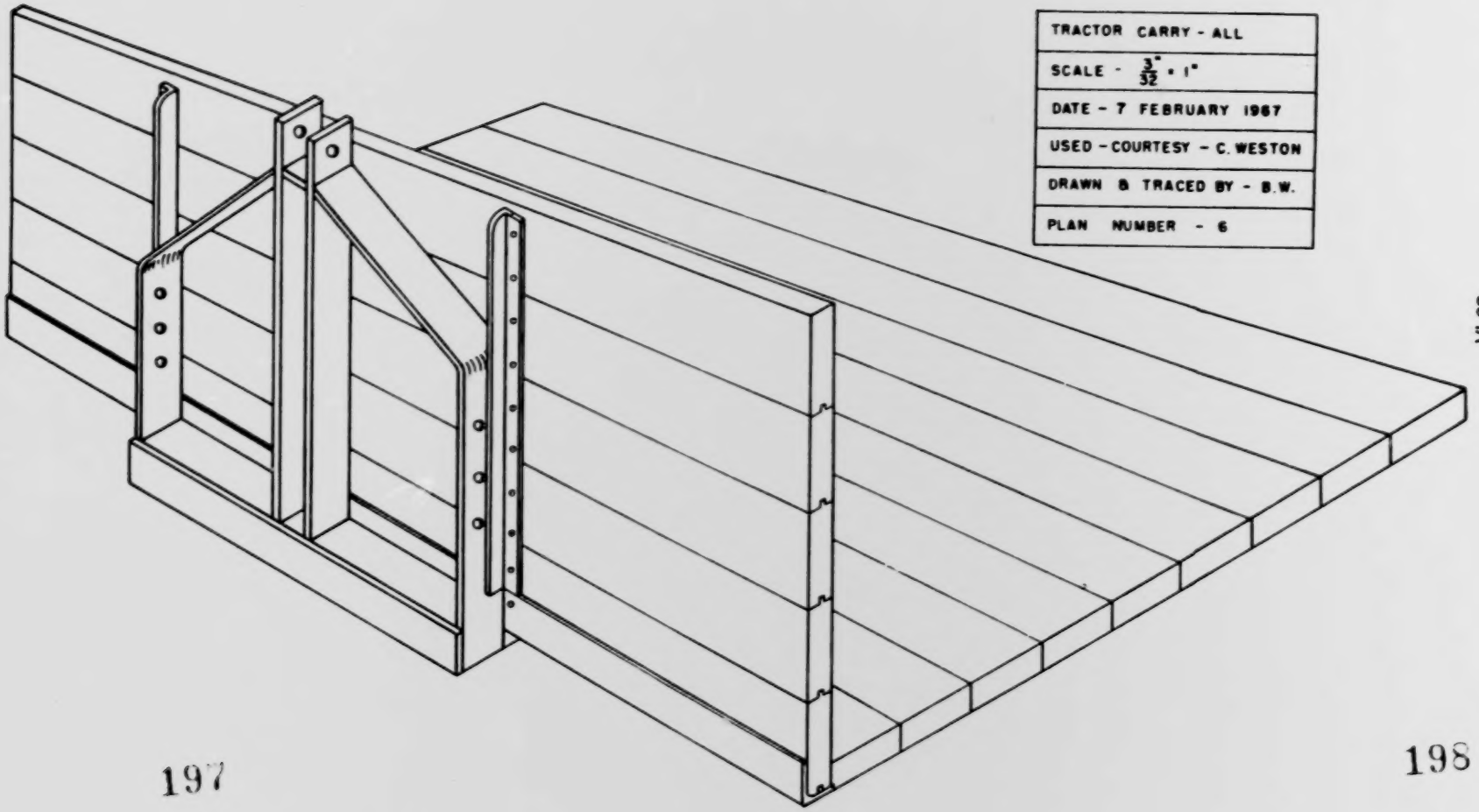
***Material Deposit is up to the instructor or business from which material was purchased.

2. Work Sheet 3.3 - Parental Permission Form for Project Material Purchase

There are no specific answers to this work sheet. It is provided for instructors to obtain permission from parents for the student to undertake the project listed. Instructors may file permission forms.

3. Work Sheet 3.3 - Where Are Materials Obtained?

There are no specific answers to this work sheet. It is provided only as a means for students to keep a record of where material is purchased.



TRACTOR CARRY - ALL
SCALE - $\frac{3}{32}$" = 1"
DATE - 7 FEBRUARY 1967
USED - COURTESY - C. WESTON
DRAWN & TRACED BY - B.W.
PLAN NUMBER - 6

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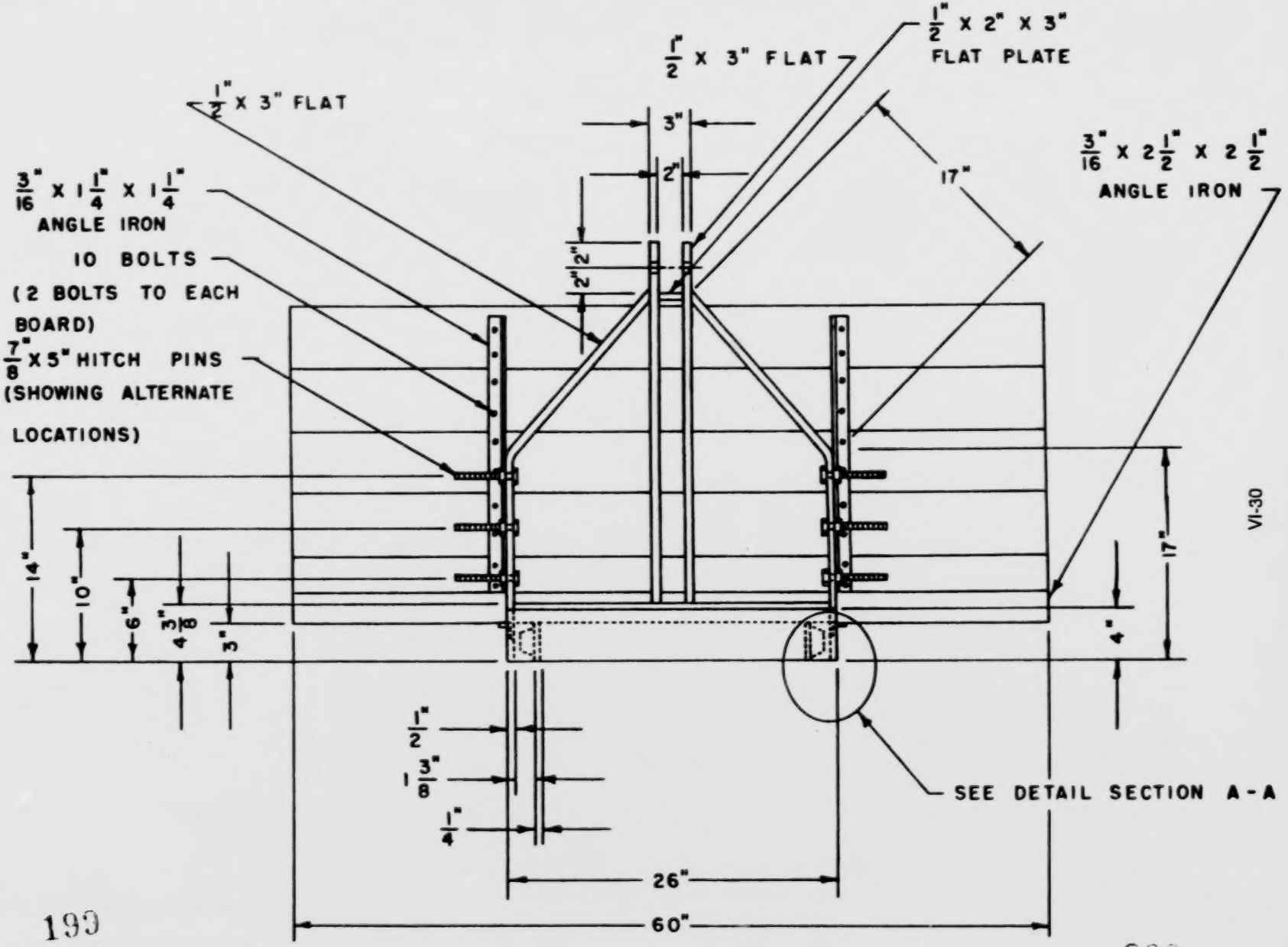
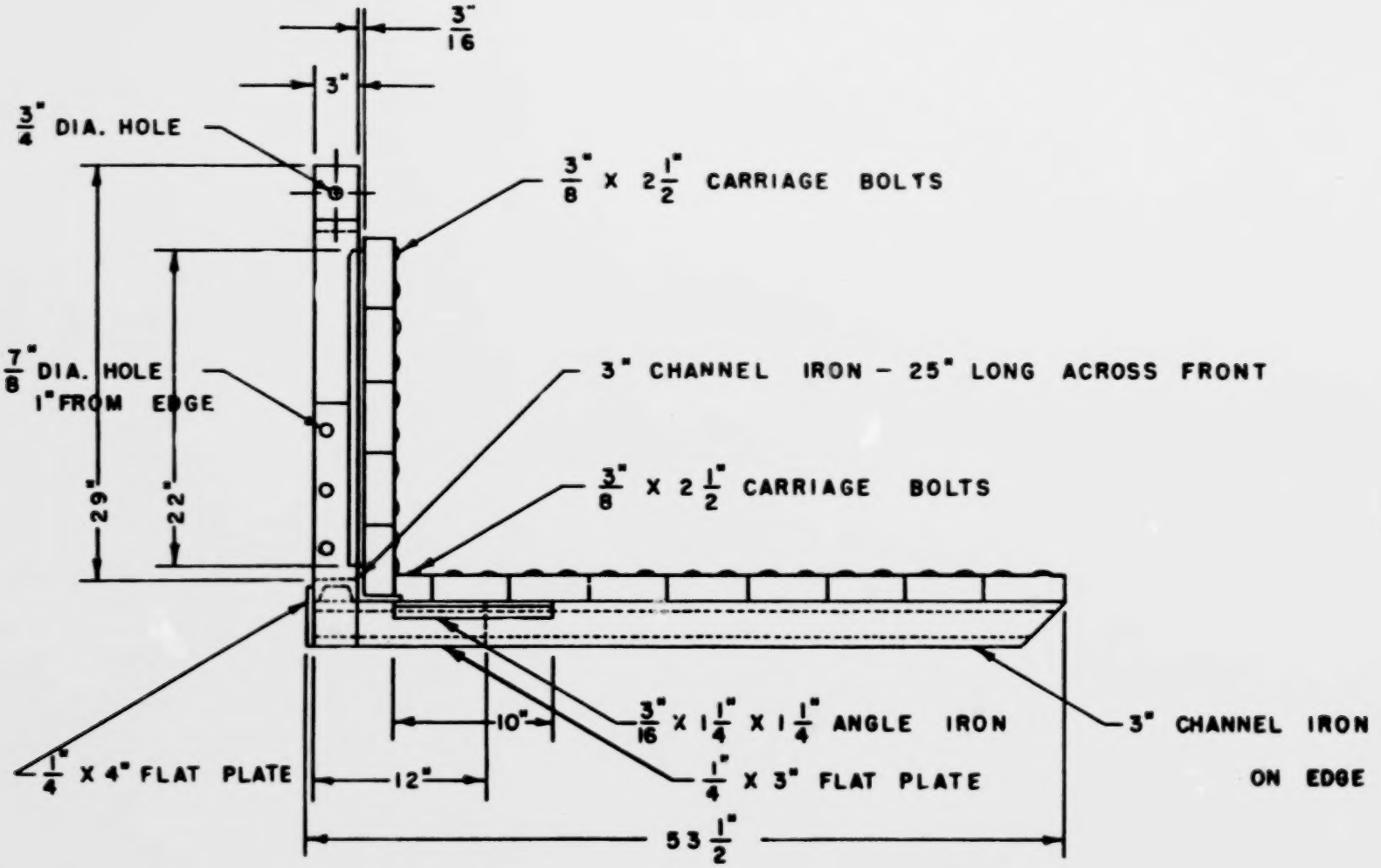


TRACTOR CARRY-ALL —— FRONT VIEW



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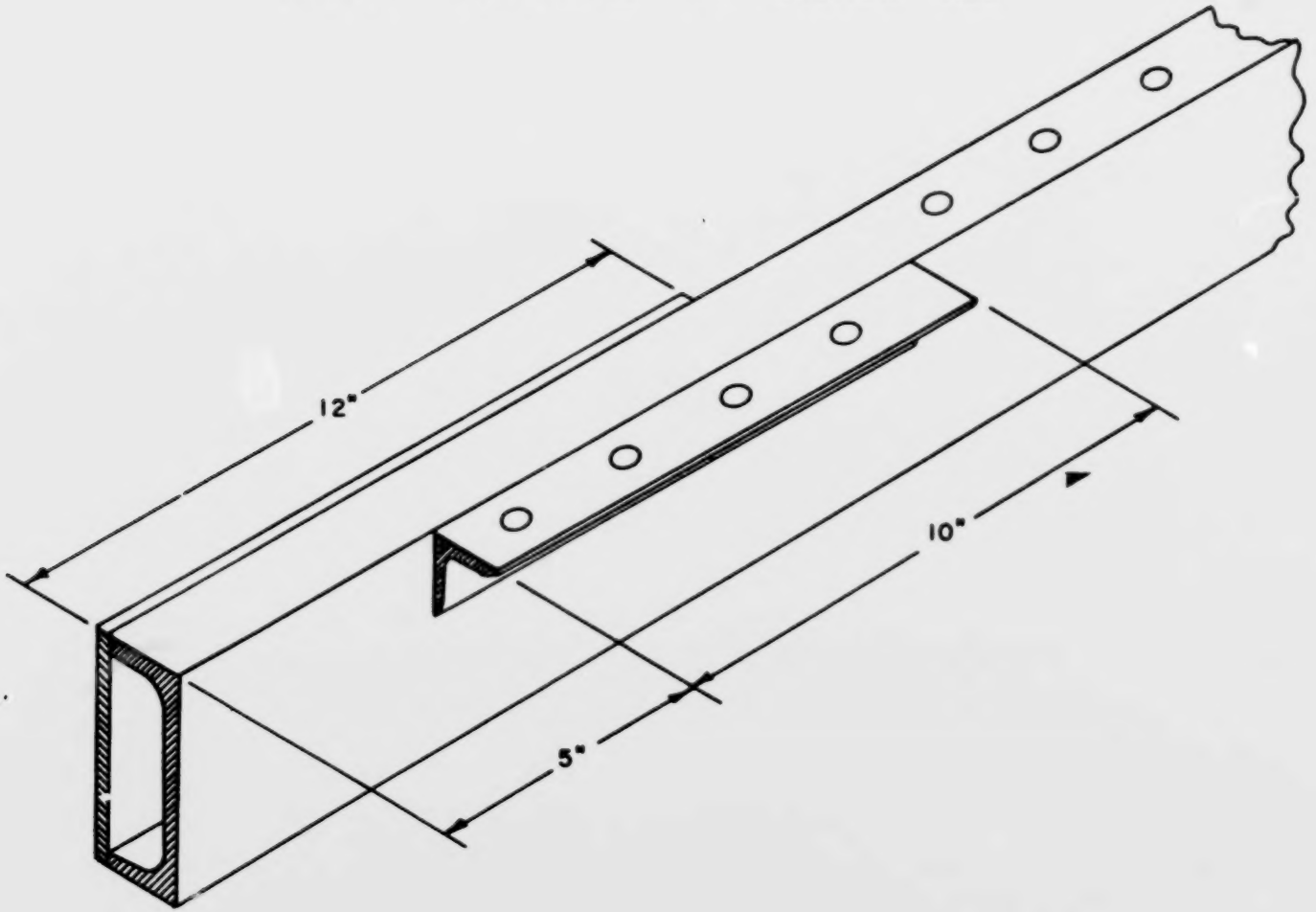
TRACTOR CARRY - ALL —— SIDE VIEW

TRACTOR CARRY - ALL — SECTION VIEW



DETAIL SECTION A - A

SCALE - 1" = 4"

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ESTIMATED BILL OF MATERIALS

STUDENT'S NAME _____ DATE _____

PROJECT TITLE _____

Estimate the materials you will need from a working drawing. Estimate the cost of the materials as accurately as possible.

No. of Pieces	Dimensions	Stock	Part & Use	Total Length	Est. Unit Cost*	Total Cost

Wastage: _____ percent Material Deposit _____ Estimated Total Cost _____

Student's Signature _____ Date _____

Parent's (Guardian's) Signature _____ Date _____

Instructor's Signature _____ Date _____

PARENTAL PERMISSION FORM FOR PROJECT MATERIAL PURCHASE

_____ HIGH SCHOOL

STUDENT NAME _____

PROJECT TITLE _____

The student has drawn up a bill of materials needed to construct this project. The estimated total cost of the project is _____. _____ (student's name) has my permission to construct this project. I realize that a down payment of _____ is to be paid before construction may begin and that the actual balance for the project will be paid in full before the project can leave school property. When the project is fully paid, it becomes the property of the student or parents.

Student's signature _____ Date _____

Parent's signature _____ Date _____

Instructor's signature _____ Date _____

WHERE ARE MATERIALS OBTAINED?

PROJECT TITLE _____

STUDENT'S NAME _____

DATE _____

SCHOOL: _____

No. of Pieces	Dimensions	Length	Stock	Part & Use

OTHER SOURCES: _____

MATERIALS PURCHASED

Name _____

Address _____

_____

Phone #_____

MATERIALS PURCHASED

Name _____

Address _____

_____

Phone #_____

UNIT VI - PROJECT CONSTRUCTION

Lesson 4: Tools and Safety Precautions Needed to Complete a Project

Objective: The student will be able to list tools needed to complete a project and list safety precautions for each tool.

References

1. Work Sheets

   a) WS 4.1: List of Tools and Procedures
   b) WS 4.2: Tools - Safety Precautions

UNIT VI - PROJECT CONSTRUCTION

Lesson 4: Tools and Safety Precautions Needed to Complete a Project

TEACHING PROCEDURES

A. Review

Review Lesson 3 on bill of materials and cost estimation. Explain to students why both the estimation of materials and the estimation of cost are important.

B. Motivation

A cookbook is used to teach one how to prepare certain dishes. Each step is needed for best results. The sequence of steps is also important. The same is true in building a project. Accuracy of the builder's measurements, the sequence of steps taken, and the craftsmanship of the builder are all reflected in the results.

C. Assignment

Students should complete WS 4.1 by writing the step-by-step procedure for construction for the tractor carry-all illustrated in HO 3.1, as well as the tools needed for each step. Tools used in the construction of the tractor carry-all should be listed on WS 4.2. Safety precautions should be listed for each tool. WS 4.1 and WS 4.2 should be used by students to outline construction procedures, tools, and safety precautions for the project(s) they plan to build in the shop.

D. Discussion

Help students set a starting point. Discuss the proper steps which need to be accomplished to complete their project. Students should use their class notes to identify safety precautions associated with the construction of their project.

E. Other activities

1. Obtain entry forms for Lincoln Arc Welding Contest. Make involvement in the contest a part of the student's grade or award extra credit.

2. Set a goal to have project entries at the state fair.

3. Organize a local display of this year's students' projects.

4. Make a special project for the high school or a local institution (e.g., hospital, nursing home, or town hall).

E. Conclusion

The order of construction is important to the successful completion of a project. Each step aids in reaching the goal of a strong and useful end product. Tool safety rules help remind students of the possible dangers involved.

F. Competency

List tools needed to complete a project and list related safety precautions.

G. Evaluation

Mastery of the competency is determined by grades given on work sheets.

H. Answers to Work Sheets

1. WS 4.1: List of Tools and Procedures

CONSTRUCTION PROCEDURE FOR TRACTOR CARRY-ALL

1. Cut all metal parts of the carry-all according to the bill of material.
2. Weld 1/4" x 3" x 12" flat iron on inside of 3" x 60" channel iron. (See detail A-A on HO 3.1.)
3. Weld 3/16" x 1 1/4" x 1 1/4" x 10" angle iron on outside of 3" x 60" channel iron. (See detail A-A on HO 3.1.)
4. Drill the three 7/8" holes in the 2 - 1/2" x 3" x 34" flat iron to receive the hitch pins. These holes are 1" from the edge of the piece.
5. Drill 3/4" holes in the 2 - 1/2" x 3" x 29" flat iron which make up the inside upright of the hitch. Clamp pieces together and drill both at one time.
6. Square 3" x 25" channel (cross piece) with 3" x 60" channel forks and weld.
7. Square outside uprights with channel iron forks and end of cross piece channel and weld on top and bottom. Be sure holes for hitch are toward the front edge.
8. Weld 1/4" x 4" x 26" flat iron reinforcement plate to front fold over ends and edges of channel iron.
9. Center the 2 - 1/2" x 3" x 29" flat uprights to be perpendicular with top of 3" x 25" channel iron and weld.
10. Heat and bend outside 1/2" x 3" x 34" uprights to inside uprights and weld.
11. Clamp the 1/2" x 2" x 3" flat iron spacer between the two uprights 4" from top of uprights and weld.
12. Weld the 3/16" x 2 1/2" x 2 1/2" x 60" angle iron across the forks and against the cross piece channel iron.
13. Weld the 3/16" x 1 1/4" x 1 1/4" x 22" angle iron flush with the angle iron cross member and to the outside 1/2" x 3" uprights.
14. Drill 3/8" holes to provide two bolts to each board used for the back and floor.
15. Paint metal parts with a rust inhibiting paint.
16. Attach all lumber to metal frame with carriage bolts.

2. WS 4.2: Tools and Safety Precautions

Power hacksaw	Secure metal in saw vise; clean chips from saw properly; handle cut metal carefully; support long stock; keep proper tension on blade; fasten saws securely; start new blade in new kerf.
Oxyacetylene cutting torch	Use approved welding goggles; fasten cylinders securely; keep safety caps on stored cylinders; check for leaking gases; never use oil on welding equipment; open acetylene cylinder correctly; keep tip pointed away from body; set operating pressures correctly; use a flint striker to light torch; never lay down a lighted torch; control flashbacks and backfires; close cylinder valves.

Arc welder	Wear eye and face protection; avoid electrical shock; protect others; never weld in damp area; protect welding cables; secure work; dispose of electrode stubs properly; use both hands in welding to avoid fatigue.
Wrenches	Do not strike wrench with hammer; do not use damaged wrenches; use wrench of proper size; pull on wrench; never extend handles.
Drill press	Secure stock; use good quality bits; tighten bit securely in chuck; anchor drill press; use a cleaning brush to remove cuttings; avoid seizing; wear proper clothing; keep work area clean; support long ends of stock; wear gloves and goggles; never attempt to stop revolving stock-cut power first; remove bit from chuck after use; attach vise permanently.
Prick punch	Recondition tools with mushroomed heads.
Radial Arm Saw	Check the stock for nails; screws and loose knots before sawing; remove wood scraps safely; pull the saw through the stock slowly to insure full control; after cutting off stock; return the saw to the column before removing stock; adjust saw stop to prevent the blade from extending beyond the front edge of the table; hold stock to insure maximum control while cutting; be sure that the stock rests against the guide strip before you start to cut; use sharp blades; tighten all locking handles securely before you begin sawing.
Spray gun	Keep covers on paint and solvent containers; clean up spill properly; keep spray area clean; store flammables properly; use equipment properly; read label; wear respirator; wear appropriate clothing; wear goggles; wear rubber gloves; work in well-ventilated areas; keep spray away from flames; locate fire extinguisher.
Air compressor	
Tape measure	
C-clamps	
Framing square	
Electric drill	

LIST OF TOOLS AND PROCEDURES WS 4.1

PROJECT TITLE: _____ PAGE _____ OF _____

STUDENT'S NAME: _____ DATE _____

STEPS IN THE CONSTRUCTION PROCEDURE TOOLS NEEDED

TOOLS - SAFETY PRECAUTIONS

PROJECT TITLE: _____ PAGE _____ OF _____

STUDENT'S NAME _____ DATE _____

TOOL	SAFETY PRECAUTIONS

UNIT VI - PROJECT CONSTRUCTION

Lesson 5: Determining a Time Frame for Completion of a Project

Objective: The student will be able to determine a time frame for completion of a project.

Reference

1. Work Sheet
   a) WS 5.1: Time Estimation Sheet

UNIT VI - PROJECT CONSTRUCTION

Lesson 5: Determining a Time Frame for Completion of a Project

TEACHING PROCEDURES

A. Review

Review with students the need for planning a project and determining tools and equipment required. Thinking through a project helps the individual know how to approach the construction of a project.

B. Motivation

There is nothing more frustrating than not being able to finish what you have started. Time is one of the limiting factors in project construction. Ask students to list reasons for estimating time needed for completion of a project. If someone is building a project to be sold, how important are the time requirements?

C. Assignment

Working as a class, have students complete WS 5.1 for the tractor carry-all used in Lesson 3. Using a second blank Time Estimation Sheet (WS 5.1), have students estimate the amount of time needed for each step in their own project. Time may depend upon degree of complexity, tool availability, tool and equipment condition, and skill of the builder. Total the amount of time needed for project completion. Is there enough time to complete such a project?

D. Supervised study

E. Discussion

Discuss how time is estimated for problem areas. Consider time lost in sick days, non-shop days, waiting for equipment, and time spent in correcting mistakes.

F. Other activities

1. Calculate the estimated labor cost after total hours needed are determined. Set a reasonable wage to teach students how real businesses figure costs. Add other costs such as materials, utilities, supplies, and tool use to determine a possible selling price.

2. Compare a project done quickly and haphazardly to a neat and precise project built carefully. Compare costs, appearance, application, selling value, and the skills developed during construction.

G. Conclusion

Knowing how much time a project will involve is important to the person building the project, the employer, and the buyer. Time estimation helps the builder realize an estimated completion date. A time frame is used as a construction schedule for the builder and the supervisor. Learning the influences of time on finances helps prepare students for the real world of production.

H. Competency

Determine the time frame for completion of a project.

I. Evaluation

The completion of the work sheet for the student's project is used to evaluate the student's performance for this lesson.

J. Answers to WS 5.1

A sample answer sheet for the tractor carry-all follows:

TIME ESTIMATION SHEET

	STEP	TIME
1.	Cut all metal to measurements.	3 hours
2.	Weld flat iron on channel.	1 hour
3.	Weld angle on channel.	1 hour
4.	Drill 3 holes in each flat iron.	1 hour
5.	Drill 3/4" holes in flat iron.	30 min.
6.	Square channel with forks; weld.	15 min.
7.	Square upright; weld top and bottom.	45 min.
8.	Weld flat iron reinforcement plate on forks.	1 hour
9.	Center upright; weld.	30 min.
10.	Heat and bend outside uprights; weld.	1 hour
11.	Clamp flat iron spacer; weld	15 min.
12.	Weld angle iron across forks and against the cross piece channel iron.	15 min.
13.	Weld angle iron flush with angle cross members.	1 hour
14.	Drill holes into boards and forms.	3 hours
15.	Prime and paint metal; preserve wood.	5 hours
16.	Fasten lumber to frame with carriage bolts.	2 hours

ESTIMATED TOTAL TIME 21 1/2 hours

TIME ESTIMATION SHEET WS 5.1

Project Title: _____

Student Name: _____

Project planned to begin on _____ (date).

Project planned to be completed on _____ (date).

STEP	TIME

ESTIMATED TOTAL TIME _____

UNIT VI - PROJECT CONSTRUCTION

Lesson 6: Interpreting the Project Plan

Objective: At the completion of this lesson, the student will be able to interpret a project plan using skills acquired in previous lessons.

References

1. Handout
   a) HO 6.1: Pipe Sawhorse
2. Work Sheet
   a) WS 6.1: Interpreting the Project Plan for a Pipe Sawhorse

UNIT VI - PROJECT CONSTRUCTION

Lesson 6: Interpreting the Project Plan

TEACHING PROCEDURES

A. Review

The previous lesson on bill of materials should be reviewed in preparation for this lesson. Information from previous lessons in the Project Construction curriculum will be used to interpret the project plan.

B. Motivation

Show students a picture of a project that could be constructed in the agricultural education shop. Ask them how they could construct one identical to it. Guide the discussion to illustrate the importance of a project plan.

C. Assignment

Students are to complete WS 6.1, "Interpreting the Project Plan for a Pipe Sawhorse," using the information found in Handout 6.1.

D. Supervised study

E. Discussion

Review the correct answers for WS 6.1, explaining answers that may have given students difficulty.

F. Other activities

1. Using project plans prepared by former students, have students answer selected questions such as materials needed to construct the project, or dimensions of the project.

2. Students should complete plans for the projects they are to construct in the shop. The plans should include a drawing, a bill of materials, and a step-by-step procedure of the order in which the work will occur.

G. Conclusion

While working in the agricultural education shop, it is important to be able to correctly interpret a project plan to save time and money, as well as to avoid wasting materials.

H. Competency

Interpret the project construction plan.

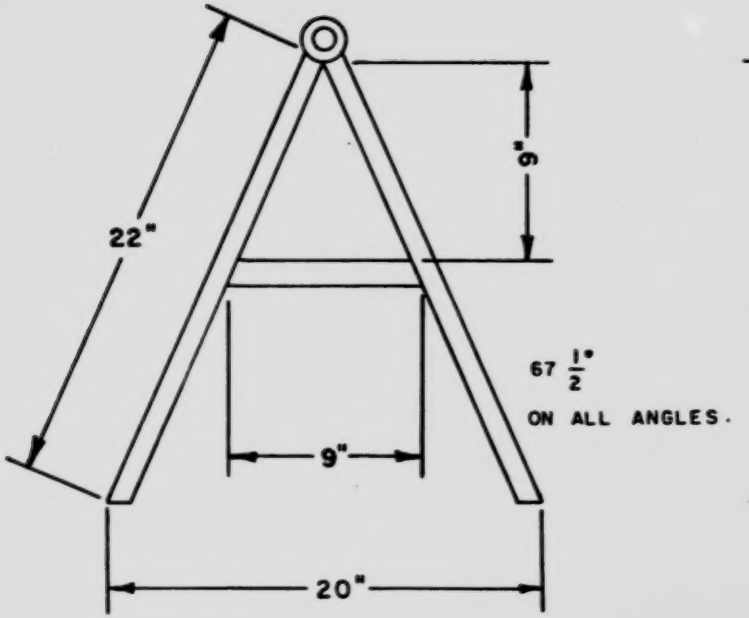
I. Evaluation

Mastery of the competency is determined by grades given on the work sheet.

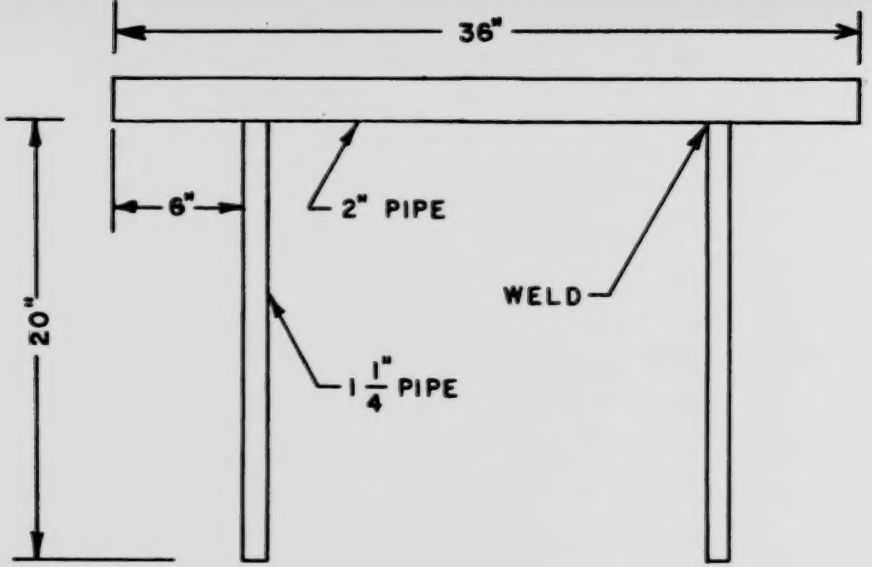
J. Answers to Work Sheet 6.1

1. 1/8" = 1"
2. 36"
3. 22"
4. 1 1/4"
5. 2"
6. 20"
7. 20"
8. 22"
9. 67 1/2 degrees
10. 6"
11. 9"
12. 67 1/2 degrees
13. 142" (11'10")

HO 6.1"



END VIEW



SIDE VIEW

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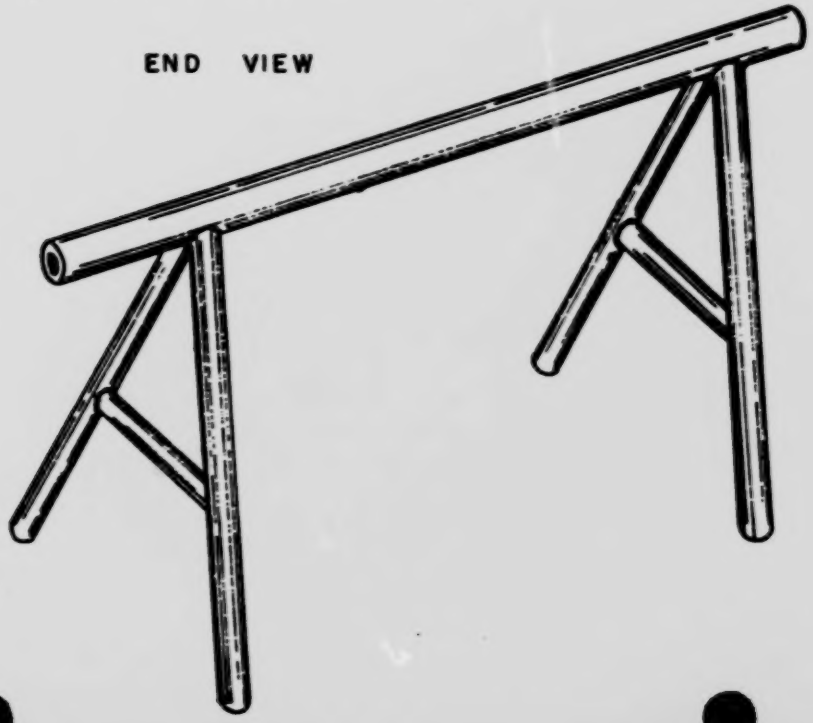


Bill of Material

1 - 2" x 36" black pipe
4 - 1 1/4" x 22" black pipe for legs
2 - 1 1/4" x 9" black pipe for braces

PIPE SAWHORSE
SCALE - 1" = 1"
DATE - 6 MARCH 1966
USED - COURTESY - C. WESTON
DRAWN & TRACED BY - B.W.
PLAN NUMBER - 103

Name _____ Date _____

Using the information on Handout 6.1, answer the following questions.

1. What scale is the project plan drawn on? _____
2. What is the total length of the sawhorse? _____
3. What is the total height of the sawhorse? _____
4. What diameter of pipe is used for the legs? _____
5. What size pipe is used for the top of the sawhorse? _____
6. What is the length from the floor to the bottom side of the top pipe? _____
7. What is the total width at the base of the sawhorse? _____
8. What is the length of each leg of the pipe sawhorse? _____
9. What degree is the angle used for the legs? _____
10. How far in are the legs set from each end? _____
11. How long is each brace for the legs? _____
12. What degree is the angle used for the braces? _____
13. How many total inches of pipe will be needed to build the sawhorse? _____

UNIT VI - PROJECT CONSTRUCTION

Lesson 7: Laying Out and Preparing Materials for Cutting

Objective: The student will be able to lay out and prepare materials for cutting.

Study Questions

1. Why is accurate layout work so important to a high quality finished project?
2. How are templates and fixtures used in material layout?
3. What tools are used for accurate layout of materials?
4. How are large holes accurately drilled?
5. How are successive cuts accomplished with precision?
6. What is a 3-4-5 triangle, and how is it used in layout work?
7. How are diagonal measurements used in laying out work?
8. Why is tack welding necessary, and how is the tack welding procedure best accomplished?
9. How are holes and cuts in metal deburred?

Reference

1. Handout
   a) HO 7.1: Laying Out and Preparing Materials for Project Construction

UNIT VI - PROJECT CONSTRUCTION

Lesson 7: Laying Out and Preparing Materials for Cutting

TEACHING PROCEDURES

A. Review

Review the importance of being able to interpret a construction plan. The ability to understand information from a plan aids the individual in applying the information to the proper construction of a project.

B. Motivation

Bring in several tools used in layout work. Some tools should be quite common to students, but other tools will be new and of interest to them. Talk briefly about specific uses of each new tool.

C. Assignment

Form teams of three or four students each. Give each team two tape measures and a piece of chalk. Have them mark corners to lay out a rectangle on the shop floor. Corners must be square. Have them determine the accuracy of the rectangle and squareness of each corner.

D. Supervised study

E. Discussion

1. The ability to do accurate layout work involves advanced skills such as thinking, evaluating, marking, and adjusting. Ask students how accurate layout may be accomplished.

   Why is accurate layout work so important to a good finished product?

   a) A mistake in layout means the piece of work may be made incorrectly.
   b) Mistakes are easiest and least expensive to correct in the layout stage.
   c) Measurements should be checked and rechecked before cutting and before other work begins.
   d) Proper layout saves time, labor, materials, and money.

2. A template or a fixture is used to save time and limit mistakes, especially when duplicate work pieces are needed. Ask students what templates or fixtures they have used in producing several identical items.

   How are templates and fixtures used in material layout?

   a) A template (templet) is a pattern for marking the shape of pieces of work or for marking holes.
   b) A fixture is a work-holding device used in production work, which allows the worker to accurately drill, cut, bend, etc.

3. Several tools are available for laying out material to be cut, drilled, or tacked. Discuss layout tools and their uses.

What tools are used for accurate layout of materials?

a) Awl
b) Center punch
c) Prick punch
d) Level
e) Plumb bob and line
f) C-clamps
g) Magnetic clamps
h) Steel rule
i) Dividers
j) Transfer punch
k) Layout fluid
l) Scriber
m) Squares - combination, framing
n) Tape measures
o) Ball peen hammer
p) Trammel

4. Drilling a hole is more involved than merely tightening a bit in a chuck and applying pressure as it rotates and cuts through the material. Ask students what other considerations should be included for proper drilling.

How are large holes accurately drilled?

a) Lay out hole for exact drilling with a prick punch.
b) Step drill to minimize oversizing of hole. Use one or more smaller drills first to remove the bulk of the material before final hole size is made.
c) Drill a pilot hole a little larger than the web of the larger drill.
d) Use cutting oil or coolant for best results.

5. Frustration abounds when one tries to make several identical-sized work pieces and nothing matches. Ask students to list ways in which pieces can be made identically.

How are successive cuts accomplished with precision?

a) Measure with accuracy.
b) Mark with accuracy.
c) Use fixtures for duplication of cuts and holes.
d) Do the following for sheet metal or flat stock:
    1) Clamp pieces together.
    2) Tack weld edges.
    3) Remove clamps.
    4) Cut or drill to desired dimension or shape.
    5) Grind off tack welds.

6. Some projects are too large to accurately check squareness with a framing square. A flexible precision method to obtain squareness involves geometry and a simple 3-4-5 triangle. Explain to students its application.

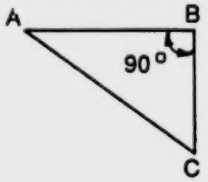
What is a 3-4-5 triangle, and how is it used in layout work?

a) The 3-4-5 triangle works because of mathematics: the Pythagorean theorem
NOTE: Pythagorean theorem - The sum of the squares of the lengths of the sides of a right triangle is equal to the square of the length of the hypotenuse. (The Pythagorean Theorem is further explained in the student handout.)

b) For a square corner, if one side measurement length is 3 and another side measurement is 4, the measurement between the two, forming a triangle, must be 5. Multiples of the 3-4-5 triangle such as 6-8-10 and 9-12-15 also work.

AB = 4; 4 squared is 16
BC = 3; 3 squared is 9

16 + 9 = 25; AC is the square root of 25
AC = 5



c) Using a tape measure and marking device, a 3-4-5 triangle can be used to lay out the right angles in a project.

7. To check the squareness of a project or work piece, the diagonals should be measured. Show students drawings of trapezoids and a rectangle. Ask which one has square corners. Sometimes lack of squareness is not obvious and measurements are the means to check accuracy.

How are diagonal measurements used in laying out work?

a) Diagonal measurements must be the same if square corners are desired.
b) Diagonal measurement must be accurate.
c) This works because of the Pythagorean theorem.

8. Tack welding saves time and materials when done properly. Ask students to list reasons for tack welding metal. What problems may result if tack welding is not performed? What is the setting of the welder for tack welding?

Why is tack welding necessary, and how is the tack welding procedure best accomplished?

a) A tack weld is a small weld, usually less than 1/2 inch long.
b) Tack welding holds metal parts in alignment and prevents distortion.
c) Slag should be chipped off prior to final welding.
d) Recheck parts for alignment and squareness after tack welding and before final welding.
e) Final weld should remelt the tack weld to insure proper penetration and fusion.

9. The rough edges of metal after being drilled or cut present a safety hazard. However, it takes very little effort to correct the situation. Ask students about the ways metal can be deburred.

How are holes and cuts in metal deburred?

a) Portable grinder - right angle grinder
b) File
c) Reamer

F. Other activities

1. The track torch is a relatively new piece of equipment available to high school shops. If the local school does not have one, ask a welding supply equipment salesperson to bring one in for demonstration.

2. Demonstrate the procedure for step drilling and realigning an eccentric hole.

3. Visit a local sheet metal shop to learn how sheet metal items are manufactured. Have students notice the equipment, labor-saving devices, and measurement methods.

4. Explain plasma arc welding and ask for a demonstration from your local welding supplies distributor.

G. Conclusion

Layout procedure is an important step in project construction. Mistakes can be corrected and adjustments made with least effort during this stage of construction. Accuracy and workmanship are the true goals.

H. Competency

Lay out and prepare materials for cutting.

I. Answers to Evaluation

1. b
2. d
3. e
4. c
5. e
6. c

Name _____

Lesson 7: Laying Out and Preparing Materials for Cutting

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. What is the best reason for using a template or fixture in material layout?

   a. It is an interesting way to figure out work.
   b. It saves time and limits mistakes in duplicating work pieces.
   c. It does the drilling, cutting, and bending for the worker.
   d. It is a machine that automatically draws patterns.
   e. It doesn't produce identical items.

2. Which of the following would <u>not</u> be used for accurate layout of materials?

   a. Level
   b. Trammel
   c. Dividers
   d. Arc welder
   e. Tape measures

3. In drilling large holes, a system called _____ is used.

   a. Layout drilling
   b. Tightened drilling
   c. Pressure drilling
   d. Pilot drilling
   e. Step drilling

4. Using the "Pythagorean theorem," if you have a triangle with one side that measures 9 and another side that measures 12, the side between the two forming a triangle would measure _____.

   a. 6
   b. 10
   c. 15
   d. 18
   e. 12

5. When cutting successive pieces of sheet or flat metal, you should do all the following except for _____.

   a. Clamping pieces together
   b. Tacking weld edges
   c. Removing clamps
   d. Cutting or drilling to desired dimension or shape
   e. Painting tack weld red

6. All of the following can be used to deburr holes and cuts in metal except for _____.

a. Portable grinder
b. Right-angle grinder
c. Wood sandpaper
d. Reamer
e. File

Project layout is a key step before actual assembly of a project begins. Project layout involves accurately measuring and cutting stock in the most efficient manner. It is important to utilize stock so as to have a minimum amount of waste. Long pieces for a project are generally laid out first from standard lengths of materials. Stock should be laid out beginning with the longest or largest and working toward the shortest or smallest. This can conserve material and save money. It is helpful to perform the project layout on paper before any material is cut to size. Don't be in a hurry to begin actual assembly of the project. Thinking ahead can save time, materials, and money.

Importance of Accurate Layout

Accurate layout is important for a high quality project. A mistake in layout means that the work piece is incorrect and may not be usable. Mistakes are easiest and least expensive to correct in the layout stage. Measurements should be checked and rechecked before any cutting or changes are made to the work pieces. Remember, proper layout saves time, labor, materials, and money.

The Use of Templates and Fixtures

In preparing stock for assembly, it is sometimes practical to use templates and fixtures. A template is a pattern for making multiple pieces to a desired shape or size. Templates are also used for laying out holes or specific measurements.

A fixture is a holding device used in production work to help the worker accurately drill, cut, bend, fasten, or perform other operations on a piece of stock. Fixtures save time and generally increase the accuracy of work.

Common Tools for Layout of Materials

Several tools are commonly used for layout of materials. The tools and their uses are described below.

1. Awl - used to scratch a mark or start a hole for screws
2. Center punch - used to mark the center of a hole
3. Prick punch - used to accurately locate points and make small punch marks
4. Level - used as a straight edge and a leveling tool
5. Plumb bob and line - used to determine vertical alignment
6. C-clamp - used to temporarily hold work
7. Steel rule - used as a straight edge and measuring device
8. Dividers - used to measure the diameter or thickness of an object
9. Transfer punch - used for accurate transferring of threaded, drilled, and tagged holes
10. Layout paint or chalk - used to increase visibility of a line or mark
11. Scriber - hardened steel tool pointed on one or both ends and used to scratch or scribe lines on metal
12. Square - used to measure and obtain squareness of corners
13. Tape measure - used to measure stock
14. Ball peen hammer - used to hammer metal and strike punches, chisels, etc.
15. Trammel - used to mark circles of various diameters

Drilling Large Holes

Proper hole drilling in material involves several considerations in order to make the job easier and safer. The speed or RPM of the drill, the type and size of the bit used, the sharpness of the bit, the need for coolant, and the material to be drilled all influence how a hole is drilled.

The use of a prick punch - Large holes are accurately drilled in the following manner. The hole is laid out for exact drilling in metal with a prick punch or center punch. An awl may be used for laying out a hole for wood.

"Step drilling" - A system called "step drilling" is used in drilling large holes. Step drilling starts by drilling a hole with a small size drill bit and working up in steps to the desired hole size. The number of step in step drilling may vary depending on the desired hole size needed.

The pilot hole - A pilot hole is the small hole used to guide a larger bit through the hole. A pilot hole should be sized slightly larger than the web of the larger drill bit. The web is the part of the bit between the flutes or cutting edges.

The use of cutting oil or coolant - Cutting oil or coolant should be used in drilling metals for best results. The coolant allows the bit to stay sharper longer and aids in cutting metal stock. Coolant also allows the equipment to work with less stress.

Cutting Identical Parts

Some projects call for several identical parts. Successive cuts can be accomplished with precision by first measuring and marking a piece with accuracy. Fixtures may be used to duplicate the act of cutting or drilling. When desiring successive cuts for sheet metal or flat stock, the following method may be used:

1. Clamp a workable number of pieces together.
2. Tack weld pieces on the edge at selected points, connecting all pieces.
3. Remove clamps.
4. Cut or drill material stack to desired dimension or shape.
5. Grind off the tack welds.

The Use of the 3-4-5 Method in Layout Work

Some projects, such as wagons and trailers, are too large to check for squareness using conventional methods. Two methods which can be used to accurately lay out and check squareness on large projects are discussed below. Both methods are based on a geometric principle called the Pythagorean theorem.

The first method involves using a tape measure and marking device to lay out a 3-4-5 triangle. A triangle with one leg 3 units long and the other leg 4 units long is illustrated in Figure 7.1. According to the Pythagorean theorem, a 90° angle will be formed at point B when the distance from A to C is equal to 5 units. See Figure 7.2.

Once this 3-4-5 triangle has been laid out and marked on the shop floor, it can be used to lay out or check corners for squareness. Multiples of the 3-4-5 triangle such as 6-8-10 or 9-12-15 may also be used.

Figure 7.1

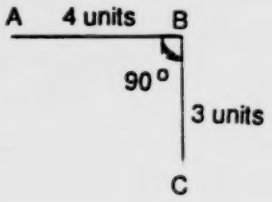
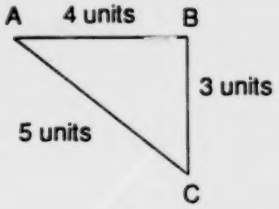


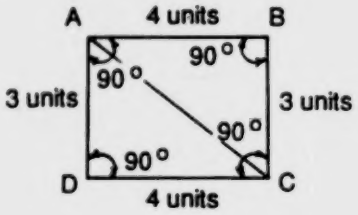
Figure 7.2



The Use of Diagonal Measurements in Layout Work

Another quick and accurate method for checking large projects for squareness is by using diagonal measurements. If all four corners of an object are square (90°), the measurement from A to C will be exactly the same as the measurement from B to D. See Figure 7.3.

Figure 7.3



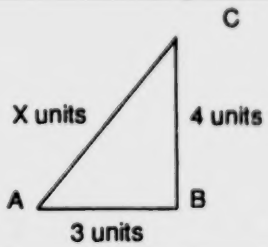
NOTE: Diagonal measurements must be made in an accurate, consistent manner.

Both of these methods of squaring large projects are based on the Pythagorean theorem. This theorem simply states that in a right triangle, the squared length of the longest side of the triangle is equal to the sum of the squared lengths of the legs of the triangle. This relationship can also be stated as an equation, $(AC)^2 = (AB)^2 + (BC)^2$.

Applying this formula to the triangle in Figure 7.4, will prove the Pythagorean theorem and will also demonstrate why the 3-4-5 method of squaring stock works.

Figure 7.4

$(AC)^2 = (AB)^2 + (BC)^2$
$(AC)^2 = 3^2 + 4^2$
$(AC)^2 = 9 + 16$
$(AC)^2 = 25$
$AC = 5$



The distance from A to C is 5 units. Therefore, it has been proven that a 3-4-5 triangle results in a triangle with a square (90°) corner.

Tack Welding Parts

Once metal parts have been properly aligned, they should be tack welded. A tack weld is a small weld which is usually less than 1/2 inch long. The purpose of the tack weld is to hold metal parts in alignment and prevent distortion during the welding operation. Slag should be chipped off the tack welds prior to final welding. The final weld should re-melt the tack weld to insure proper penetration and fusion.

NOTE: Parts should be re-checked for alignment and squareness after tack welding and prior to final welding. If parts are out of alignment or are not square, the tack welds should be ground down and the pieces should be realigned or squared. Re-checking parts prior to final welding can prevent wasting time, materials, and money.

Deburring Holes

Holes that are drilled should be deburred for safety and appearance's sake. The metal remaining on the edge of metal following cutting or drilling is called the burr. Burrs are best removed from flat surfaces with a portable grinder, file, or reamer.

UNIT VI - PROJECT CONSTRUCTION

Lesson 8: Determining the Construction Design for Proper Hitching and Balancing

Objective: The student will be able to determine proper hitching and balancing in construction design.

Study Questions

1. **How is the center of a trailer's load determined?**
2. **What is hitch weight, and how is it determined?**
3. **What is the limiting factor for hitch weight?**
4. **What is the advantage in using multiple axles?**
5. **What aspects are considered in selecting components for a trailer?**
6. **What is hitch length, and how is it determined?**
7. **How does trailer design and capacity influence selection of trailer ball size?**

Reference

1. Handout
   a) HO 8.1: Hitching and Balancing

Lesson 8: Determining the Construction Design for Proper Hitching and Balancing

TEACHING PROCEDURES

A. Review

Review the previous lesson involving project layout and the cutting of parts. Emphasize the importance of accuracy in measurement, squareness, and cutting procedure.

B. Motivation

Display a short length of chain with links made of various materials such as string, rope, and wires of different gauges. Ask students to determine the weakest link. How much weight can be attached to the end of the chain before a link will break?

Bring in a tire and have a student read, from the tire's side, the maximum pressure and maximum load. Ask students if this tire could be the "weakest link" in the loading of a trailer. Discuss other trailer components and their influence on trailer capacity.

C. Assignment

D. Supervised study

E. Discussion

1. The balancing of a trailer is influenced by what is to be carried. Trailers haul a variety of items. Ask students to evenly distribute 10 50-pound bales of hay on a suitable trailer. Use 2-inch by 4-inch wood blocks as miniature bales if needed.

   How is the center of a trailer's load determined?

   a) Determine maximum load to be carried.
   b) Divide trailer load by trailer length.
   c) Distribute load evenly onto trailer bed.
   d) Center of load will be the point where half of the load is situated on the front and half on the back.
   e) The trailer is now balanced; no excess weight exists on front or back. However, this is not the condition desired for pulling.

2. Hitch weight is an important aspect in trailer design. A single- or multiple-axle trailer that is balanced would have zero hitch weight. Hitch weight is needed for safe control of the trailer. Show students with a miniature single-axle trailer why hitch weight is needed.

   What is hitch weight, and how is it determined?

   a) Hitch weight is the loaded trailer's tongue weight on the towing vehicle.
   b) Bumper-type (tag-along) hitch - Ten to 12 percent of the load should be placed on towing vehicle's bumper.
   c) Gooseneck-type hitch - Eighteen to 25 percent of the load should be placed on towing vehicle's bed.

d) Hitch weight is calculated using the following formula:

Hitch Weight = L × X / Y, where L = load in pounds, X = the distance from the center of the bed to the center of the axle, and Y = the distance from the front end of the tongue to the center of the axle.

3. The vehicle pulling a trailer must be capable of handling the load placed upon it. Ask students to list reasons why manufacturers set load capacities for their vehicles.

What is the limiting factor for hitch weight?

a) The towing vehicle's hauling weight capacity limits the hitch weight.
b) A 1-ton truck has a load capacity of 1 ton unless altered for a greater load (i.e. heavier springs, etc.).
c) Trailer balls are divided into classes, based on the size of the ball and shaft. The larger the ball size, the greater load capacity.
   1) Class I - up to 2,000 lbs. gross trailer weight (GTW); 200 lbs. tongue weight; attached to bumper only
   2) Class II - up to 3,500 lbs. GTW; 300 lbs. tongue weight; attached to bumper or frame
   3) Class III - 5,000 lbs. GTW; 500 lbs. tongue weight; attached to bumper and hitch; receiver-type hitch
   4) Class IV - 10,000 lbs. GTW; 10,000 lbs. tongue weight; attached to bumper and frame; receiver-type hitch; weight distributed hitch

4. The design of some trailers may warrant more than one axle. Ask students to list uses for trailers with one, two, and three axles.

What is the advantage of using multiple axles?

a) Multiple axles distribute the weight of the load more evenly and efficiently.
b) Multiple axle design adds strength to the system.

5. Many components are used in the construction of a project. In trailer construction, the safety, strength, and suitability of materials and construction design influence the reliability of the implement. Ask students to consider consequences should a component fail. Refer to Appendix C for a computer program that may be entered onto a disk for and used with this lesson, based on the type of computer available.

What aspects are considered in selecting components for a trailer?

a) The weakest point in a trailer's design must be strong enough to carry the planned maximum load.
b) Heavier duty components than required should be selected.

6. It would be foolish to build a trailer with an excessively long or short tongue. Ask students to list reasons for proper tongue length. Demonstrate turning radius with a vehicle. Show how adding a trailer to the vehicle increases the turning radius.

What is hitch length, and how is it determined?

a) Hitch length is the distance from the center of ball hitch to the front of bed.
b) Hitch length should be long enough to obtain desired turning radius without damaging the trailer or towing vehicle.

c) Recommended length for bumper hitches is 3 1/2 feet.
d) A minimum of 6 1/2 feet for gooseneck trailers is required.

7. Bring in several sizes of trailer balls. Allow students to compare the differences among the balls and shanks. How are ball sizes selected?

How does trailer design and capacity influence selection of trailer ball size?

a) Balls are rated according to gross trailer weight. The ball selected should be rated (in pounds) equal to or greater than the gross trailer weight. For example, if the combined weight of the trailer and bed equals 14,000 lbs., the ball selected should be rated at or above 14,000 lbs. A ball with more than a minimum rating should be selected if possible.
b) Balls are divided into four classes, based on size of the ball and shaft.
   1) Class I - 1 7/8" ball with 5/6" or 3/4" shaft - 2,000 lb weight rating
   2) Class II - 2" ball with 3/4" shaft - 3,500 to 4,000 lb weight rating
   3) Class III - 2" ball with 1" shaft - 5,000 lb weight rating
   4) Class IV - 2" or 2 5/16" ball, 1 1/4" (6,000 - 10,000 lb weight rating) or 1 3/8" shaft - (13,000 - 30,000 lb weight rating)

F. Other activities

1. Visit an implement dealer and view various implement designs. Take note of axle placement, tongue length, and tire size.

2. Calculate load capacity of a pickup truck after installation of heavy duty leaf springs and shock absorbers.

3. Send for information from trailer manufacturers and compare designs of each, including axle placement and hitch lengths and types.

G. Conclusion

Trailers must be hitched and balanced properly for safe and reliable operation. Aspects of weight capacity, hitch weight, and load distributions should be considered.

H. Competency

Determine construction design for proper hitching and balancing.

I. Answers to Evaluation

1. b
2. d
3. b
4. e
5. a
6. a
7. b
8. a
9. b
10. b

UNIT - PROJECT CONSTRUCTION

Name _____

Lesson 8: Determining the Construction Design for Proper Hitching and Balancing

Date _____

EVALUATION

Circle the letter that corresponds to the correct answer.

1. The formula for determining center of load is _____.

   a. Trailer load + hitch height
   b. Trailer load + trailer length
   c. Trailer length + trailer load
   d. Trailer width + trailer height
   e. Trailer load + trailer height

2. The maximum load that may be carried by a 1/2-ton pickup is _____.

   a. 500 lbs.
   b. 2,000 lbs.
   c. 750 lbs.
   d. 1,000 lbs.
   e. 1,500 lbs.

3. Which of the following may be used to increase the maximum load of a towing vehicle?

   a. Double break pads
   b. Heavy duty springs
   c. Positive traction rear-end
   d. Smaller diameter hitch ball
   e. Narrower tires

4. Calculate the hitch weight for the following trailer. There is a 16 ft. distance from the tongue to the center of the axle. A 2 ft. distance exists from the center of the bed to the center of the axle. The trailer will carry an 800 lb. load. The hitch weight for the trailer will be _____.

   a. 75 lbs.
   b. 250 lbs.
   c. 500 lbs.
   d. 200 lbs.
   e. 100 lbs.

5. What percentage of the hitch weight may be safely placed on the bumper while towing?

   a. 12%
   b. 5%
   c. 50%
   d. 100%
   e. 25%

6. A tandem-axle trailer pulls easier and is safer than a single-axle trailer.

   a. True
   b. False

7. If the weight of the load cannot be distributed evenly, more weight should be placed on the back of the trailer than on the front.

   a. True
   b. False

8. The weakest point in a trailer's design must be strong enough to carry the maximum load.

   a. True
   b. False

9. As tongue length increases, the trailer becomes harder to handle and turn.

   a. True
   b. False

10. As the amount of weight being hauled increases, a smaller ball size is recommended.

    a. True
    b. False

A trailer must trail the towing vehicle safely and properly. The design and construction of a trailer affects the way a trailer will handle when in motion. The aspects of design that must be considered include the center of load, hitch weight, axle capacity, bed height, tire capacity, and ball size.

Determining the Center of Load

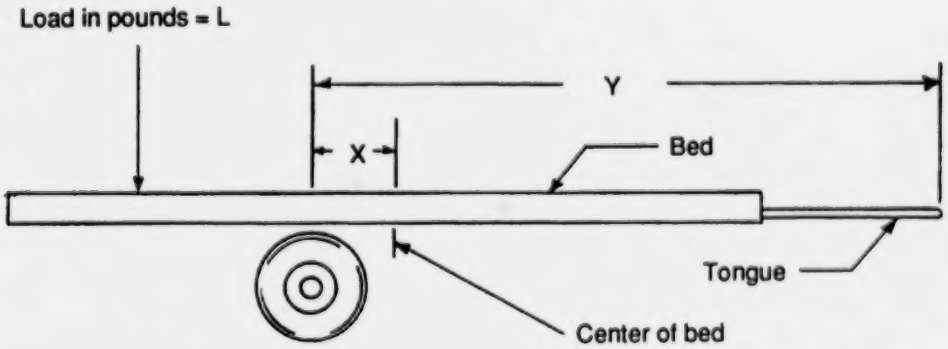
It is important to determine the maximum load that a trailer can carry before loading. In order to determine the center of load, the trailer load is divided by trailer length. The center of load is the point where half of the load is situated on the front and half on the back. Though this will result in a balanced load, this situation is not ideal for pulling.

Hitch Weight

Proper hitch weight should be determined. Every vehicle has a maximum load it is designed to carry. For instance, a stock 1/2-ton pickup truck has a capacity of 1/2 ton, or 1,000 pounds. The capacity may be increased by installing heavy-duty springs and heavy-duty shock absorbers. The weight of the hitch should not be more than the capacity of the towing vehicle.

If an implement is pulled by a hitch on the bumper of the towing vehicle, not more than 10 to 12 percent of the loaded implement's weight should be placed on the bumper. If an implement is hitched on the bed of the towing vehicle, as with a fifth wheel design, not more than 18 to 25 percent of the loaded implement's weight should be placed on the towing vehicle.

A loaded trailer should not weigh more than the vehicle towing it, or braking problems will result. Calculate the maximum weight to be carried on the trailer. Assume a uniform load when calculating capacity by imagining the trailer's payload being grain or blocks of ice.



L = Load in pounds
X = Distance axle back from the center (feet)
Y = Distance from tongue to axle center (feet)

$$\text{Hitch Weight} = \frac{L * X}{Y}$$

Axle Capacity

Axle capacity is another important consideration in safe and proper trailer design. A single-axle capacity can be rated from 3,000 pounds to 10,000 pounds. Generally, as the capacity of the axle increases, the braking system gets bigger and better. It is recommended that a heavier-duty axle be selected than is needed. When larger capacity axles are used in tandem or triple design, weight is distributed more efficiently. A tandem-axle trailer pulls easier, is safer, and rides more smoothly than a single-axle trailer. Less dragging occurs with a tandem-axle design than a triple-axle design. The center axle in a triple axle design is apt to depart from alignment.

If the weight of the payload cannot be evenly distributed, as in carrying a tractor, the person in charge should situate the payload so that more weight is to the front of the trailer's axles, and the trailer pulls true. Stops may be attached or lines may be painted for easy and correct placement.

Selecting Trailer Components

The trailer's bed height, width, and length should be suitable to the loads that are to be carried as well as proportional and pleasing to the eye. In designing a trailer, one should first determine its uses and various payloads. Proper dimensions may then be assigned.

The weakest point in a trailer's design must be strong enough to carry the maximum load. One should select heavier-duty axles and couplers than required and let the tires selected be the weakest point. Tires are easiest to control regarding capacity and least expensive to replace.

The wheel and tire capacities of the trailer must also be considered. The capacity of a tire is written on its side along with maximum pounds per square inch (psi). These capacities should not be exceeded.

It is suggested that the tire size of the towed implement match the tire size of the towing vehicle. This coordination is convenient in the event a spare is needed.

Hitch Length

The point and the length of hitch should also be considered in constructing a trailer. As the tongue length increases, the trailer becomes easier to handle and to turn. A tongue length of 3 1/2 feet is generally recommended for trailers that are to be hitched to bumpers. This distance allows ample clearance in sharp turns and relatively easy handling. Three and one-half feet represents the distance from the center of the ball hitch to the trailer body front. Every trailer and pulling vehicle should be considered case by case in designing a tongue length.

Gooseneck trailers generally hitch in the center of the truck's bed at a point on or slightly in front of the rear axle of the vehicle. The "neck" of the gooseneck trailer should be approximately 6 1/2 to 7 feet from the bed of the trailer.

Ball Size

Ball sizes may range from 1 7/8 inches, often used with boat trailer, to 3 inches, used for excessively heavy loads. Balls are rated according to the trailer weight. For example, if a trailer is designed to haul 24,000 lbs., the ball should have at least a 24,000 lb. rating. You should select a higher rated ball when possible. Table 8.1 shows the different classes for ball sizes.

Table 8.1	Ball Size Classifications	Weight Rating
Class I	1 7/8" ball with 5/6" or 3/4" shaft	2,000 lbs.
Class II	2" ball with a 3/4" shaft	3,500-4,000 lbs.
Class III	2" ball with a 1" shaft	5,000 lbs.
Class IV	2" or 2 5/16" ball,	
	with a 1 1/4" shaft	6,000 - 10,000 lbs.
	with a 1 3/8" shaft	13,000 - 30,000 lbs.

UNIT VI - PROJECT CONSTRUCTION

Lesson 9: Determining the Construction Design for Legal Specifications of a Project

Objective: The student will be able to determine if the construction design meets all legal specifications of the state.

Study Questions

1. **What is the legal maximum width of vehicles and pulled implements in Missouri?**
2. **What is the legal total length of a pulled implement and towing unit in Missouri?**
3. **What is the legal total weight limit for a pulled implement and towing unit in Missouri?**
4. **What is the legal height limit for a vehicle or pulled implement in Missouri?**
5. **What are the legal requirements for lighting of a pulled implement in Missouri?**
6. **Why are brakes and safety chains recommended for towed implements?**

References

1. Missouri Highway Patrol, Commercial Motor Vehicle Division, 1510 E Elm, Jefferson City, MO 65101.
2. Missouri Motor Carriers Association, P.O. Box 1247 - 201 East Capitol, Jefferson City, Missouri 65102.
3. Handout
   a) HO 9.1: Legal Specifications for Implements

UNIT VI - PROJECT CONSTRUCTION

Lesson 9: Determining the Construction Design for Legal Specifications of a Project

TEACHING PROCEDURES

A. Review

Review the previous lesson, stressing the importance of proper hitching and balancing design for trailers and other implements used in agriculture.

B. Motivation

Constructing a project with little concern for safety or legality will ultimately cause trouble for the builder, the user, or innocent others. Laws are made for the safety of the public. Bring in photographs of a jackknifed trailer truck or a mangled trailer after an accident, or clip news stories of accidents caused by neglect. For information on current legal specifications, contact the Missouri State Highway Patrol, Commercial Motor Vehicle Division, 1510 E. Elm, Jefferson City, MO 65101, (314) 751-3313 or the Missouri Motor Carriers Association, P.O. Box 1247 - 201 East Capitol, Jefferson City, Missouri 65102.

C. Assignment

D. Supervised study

E. Discussion

1. Most agricultural implements are transported on rural roads and highways. Ask students to determine why the width of vehicles and implements must be limited. How do oversized implements cause problems?

   What is the legal maximum width of vehicles and pulled implements in Missouri?

   a) The legal width limit of vehicles on most roads in Missouri is 8 feet.
   b) The legal width limit of vehicles on interstate highways and designated roads and roads within 10 air miles is 8 1/2 feet.
   c) Any vehicle with a width of more than 8 or 8 1/2 feet, respectively, traveling on roads requires a special permit.

2. Bring in a toy pickup truck and gooseneck trailer. Ask students to determine scale. How long is the truck, the trailer, and the combination?

   What is the legal total length of a pulled implement and towing unit in Missouri?

   a) The total length of towing unit plus towed unit on or within ten miles of an interstate highway or designated road cannot exceed 65 feet from the front of the towing unit to the rear of the towed implement
   b) Maximum length of implements and the towing unit on supplemental roads is 55 feet.
   c) The width and length restrictions do not apply to agricultural implements operated for short distances or to temporarily transport agricultural implements or road machinery. The above restrictions do not apply to implement dealers delivering or moving farm machinery for repairs.

3. Explain gross vehicle weight with a toy pickup truck and trailer. Give a gross vehicle weight (GVW) for a known pickup truck and ask students to determine the number of market animals that can legally be carried in the stock trailer. Include empty trailer weight and weights of animals.

What is the legal total weight limit for a pulled implement and towing unit in Missouri?

a) The weight of the towing unit, the empty towed unit, and the load being carried cannot exceed the vehicle's licensed gross vehicle weight (GVW).

b) Load limits for single- and multiple-axles are the following:

Type of axle	Center front to center back wheel distance	Type of highway	Load weight limit
Single axle	not applicable	Supp. bridge	18,000 lbs.
	not applicable	Interstate	20,000 lbs.
	not applicable	Primary	22,000 lbs.
	not applicable	Commercial	22,400 lbs.
Double axle (tandem)	not applicable	Supplementary	32,000 lbs.
	not applicable	Interstate	34,000 lbs.
	not applicable	Primary	36,000 lbs.
Triple axle	$\leq$ 8 feet	All roads (not	34,000 lbs.
	8 1/2 feet	commercial)	42,000 lbs.
	9 feet		42,500 lbs.

c) Vehicles registered to carry or tow loads greater than 12,000 pounds are required to stop at highway weighing scales.

4. Bring in a news photo of a trailer truck wedged in an underpass. Ask students if they have ever viewed such a scene in real life. Approximately how high are most underpasses? How high are most high tension electric lines?

What is the legal height limit for a vehicle or pulled implement?

a) The legal height limit for a vehicle or pulled implement is 14 feet maximum from ground to the highest point of the implement or vehicle.

5. Inspect the lighting system of a trailer. Ask students the following questions: What energizes the lights? How are they controlled? How are lighting problems solved? Discuss the flasher system and fuses.

What are the legal requirements for lighting of a pulled implement in Missouri?

a) A license plate light is required that will allow the license plate to be read at a distance of 50 feet.

b) Lighting is only required when the trailer is so wide that someone following you could not see hand signals. This distance is usually 2 1/2 feet. Lighting consists of two red stop lamps, two amber or red turning lamps, and two red

reflectors. If you intend to pull the trailer out of the State of Missouri, you must meet Federal Motor Carrier requirements. For example, if the combined length of the bed of your gooseneck and the neck of the gooseneck is greater than 30 feet, three clearance lights, rather than two, are required (two amber and one red).

6. Discuss the importance of safety chains when towing a trailer.

Why are brakes and safety chains recommended?

a) A safeguard against a runaway implement
b) Liability protection
c) Safety chains are required if the trailer exceeds 3,000 lbs. The chain must also be rated as you would size the ball for your trailer.
d) *Brakes are required on all wheels of the trailer if the trailer exceeds 3,000 lbs gross vehicle weight or if the weight of the trailer exceeds 40 percent of the gross vehicle weight of the truck, pickup or car.

*At the time this was written, the State of Missouri did not require this for farm trailers. However, even if you own a farm trailer and you use it out of state, for any reason, the trailer must meet Federal Motor Carrier requirements. Brakes and chains are just one of these requirements.

F. Other activities

1. Invite a local truck dealer to visit the class and speak about vehicle weights and hookup safety.

2. Prepare a bulletin board comparing a properly loaded trailer and an improperly loaded trailer. The extension office may have information on transporting livestock.

3. Hook up the lighting for a mock trailer made of wood and plywood. Troubleshoot the lighting system.

4. Visit the local elevator scales to weigh a pickup truck and empty trailer. Present problems for the class to solve concerning legal load weights.

G. Conclusion

Laws for the road exist for the protection and safety of the public. Laws for vehicles and implements not only affect the builder of the implement but also the driver and the traveler.

H. Competency

Determine construction design for legal specifications: width, length, weight, etc.

I. Answers to Evaluation

1.	c	6.	d
2.	e	7.	c
3.	d	8.	d
4.	c	9.	b
5.	a	10.	b

Name _____

Lesson 9: Determining the Construction Design for Legal Specifications of a Project

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. The legal maximum width of vehicles and pulled implements on most Missouri roads (without a special permit) is _____.

   a. 6 feet
   b. 7 feet
   c. 8 feet
   d. 9 feet
   e. 10 feet

2. The legal total length for a pulled implement and towing unit to be used on Missouri roads cannot exceed _____.

   a. 40 feet
   b. 45 feet
   c. 50 feet
   d. 60 feet
   e. 65 feet

3. When dealing with loads and trucks, the letter GVW stand for _____.

   a. Greatest vertical wobble
   b. Government variability weight
   c. Greatest vehicle width
   d. Gross vehicle weight
   e. Government vehicle waver

4. The legal height for a vehicle or pulled implement cannot exceed_____.

   a. 10 feet, 6 inches
   b. 12 feet, 0 inches
   c. 14 feet, 0 inches
   d. 15 feet, 0 inches
   e. 20 feet, 0 inches

5. Which of the following lights is required on every trailer being pulled on Missouri roads?

   a. License plate light
   b. Blinkers
   c. Flashers
   d. Headlights
   e. Courtesy lights

6. Safety chains on trailers act as _____.

   a. The weakest link in the system
   b. The strongest link in the system
   c. A means to true pull of the trailer
   d. A safeguard against a runaway implement
   e. An aid in turning

7. The maximum length of a trailer that is to be towed on or within 10 miles of an interstate highway is _____.

   a. 45 ft.
   b. 55 ft.
   c. 65 ft.
   d. 30 ft.
   e. 100 ft.

8. The license plate light on a trailer must be visible from _____.

   a. 100 ft.
   b. 10 ft.
   c. 85 ft.
   d. 50 ft.
   e. 70 ft.

9. Brakes are required on all wheels if the weight of the towed unit is greater than _____ of the gross vehicle weight of the towing unit.

   a. 80 percent
   b. 40 percent
   c. 30 percent
   d. 50 percent
   e. 25 percent

10. The maximum length of a trailer and towing unit on supplemental roads is _____.

    a. 30 ft.
    b. 55 ft.
    c. 65 ft.
    d. 70 ft.
    e. 45 ft.

The State Highway Patrol enforces the laws of the road in Missouri. Laws are meant to protect the public in keeping the roads and highways as safe as possible. It is the responsibility of the designer, builder, and user of implements to meet the legal specifications set by the state. The state has laws specifying width, length, height, weight, and lighting of implements using Missouri roads.

Width

The standard maximum width of a vehicle or implement is 8 feet. However, implements transported on interstate highways, other designated highways, and roads 10 air miles from those highways can be 8 1/2 feet wide. This law was set for commercial truckers but applies to any user. A special permit is required on any road for loads wider than the legal limit.

Length

The total length of the vehicle and its towed implement on or within a ten mile area of an interstate highway cannot exceed 65 feet from the front of the towing unit to the rear of the towed implement. Maximum length for supplementary roads is 55 feet. The length and width limits listed above do not apply to agricultural implements operated for short distances or to temporarily transport agricultural implements or road machinery, nor do they apply to implement dealers delivering or moving farm machinery for repair.

Weight

Every truck is licensed for a specific gross vehicle weight (GVW). The person registering the vehicle may specify the gross vehicle weight as determined by its planned use. The total weight of the vehicle, its passengers, the towed implement, and its payload are included. Any vehicle registered or licensed for loads greater than 12,000 pounds is required to stop at weighing stations on the highway.

Load limits for single- and multiple-axles are listed below.

Type of axle	Center front to center back wheel distance	Type of highway	Load weight limit
Single axle	not applicable	Supp. bridge	18,000 lbs.
	not applicable	Interstate	20,000 lbs.
	not applicable	Primary	22,000 lbs.
	not applicable	Commercial	22,400 lbs.
Double axle (tandem)	not applicable	Supplementary	32,000 lbs.
	not applicable	Interstate	34,000 lbs.
	not applicable	Primary	36,000 lbs.
Triple axle	$\leq$ 8 feet	All roads (not	34,000 lbs.
	8 1/2 feet	commercial)	42,000 lbs.
	9 feet		42,500 lbs.

Height

Vehicles and towed implements must not be more than 14 feet in height for transport on a highway or road. Height measurement is taken from the ground to the uppermost part of the vehicle or implement.

Lighting

A license plate light is required that will allow the license plate to be read at a distance of 50 feet. Lighting is only required when the trailer is so wide that someone following you could not see hand signals. This distance is usually 2 1/2 feet. Lighting consists of two red stop lamps, two amber or red turning lamps, and two red reflectors.

***Safety Chains and Brakes**

The use of safety chains and brakes on trailers safeguards against a runaway implement and serves as liability protection in case of an accident. It is better to be safe than sorry. If the weight of the towed unit is greater than 40 percent of the gross vehicle weight of the towing unit, brakes are required on all wheels.

*Any time a trailer, even though it was intended for farm use, is pulled out of state, the trailer must meet or exceed Federal Motor Carrier requirements. Failure to do so leaves the operator liable in the event of an accident -- even if the operator was not at fault.

UNIT VI - PROJECT CONSTRUCTION

Lesson 10: Identifying and Correcting Project Defects by Approved Methods

Objective: The student will be able to identify and correct project defects by approved methods.

Reference

1. Work Sheet

   a) WS 10.1: Quality Control - Project Evaluation Check List

UNIT VI - PROJECT CONSTRUCTION

Lesson 10: Identifying and Correcting Project Defects by Approved Methods

TEACHING PROCEDURES

A. Review

Review the previous lesson regarding legal specifications. Why are they necessary? On whom does liability lie?

B. Motivation

A true craftsman desires the best possible finished product. Show students two or more of the same type of project. Have students choose the one they would purchase. What criteria did they use in making their selections? What is wrong with the one they didn't choose? If they were to build a similar item, what changes would they make?

C. Assignment

Using the check list, the instructor should evaluate a completed project. Discuss with students the reason why a check list is helpful when evaluating a project. The students should use the check list during construction when changes can be made easily, as well as on the finished project.

D. Supervised study

E. Discussion

Involve students in the evaluation of the project. Ask the class what they like and dislike about the project? How can corrections best be made? Stress the importance of craftsmanship in a positive way.

F. Other activities

1. Set a goal of 100 percent participation by students in a state fair project construction contest.

2. Invite an implement dealer or other experienced machinery person to judge students' projects.

3. Take photographs of students and their projects, and construct a bulletin board for the school.

4. Assign students to write a report on quality control and its importance.

G. Conclusion

Self-evaluation teaches students to improve their own work as well as to appreciate high standards. Mistakes and defects should be corrected for the best possible end product.

H. Competency

Identify and correct project defects by approved methods.

I. Evaluation

Review project evaluation check list (WS 10.1) with each student to determine if project defects have been identified and corrected.

Carefully inspect your project. Use this check list to evaluate your project during construction as well as upon completion. Write yes or no in the blank before each question. If the question does not apply to your project, write "N/A" in the blank. Make notes of necessary changes. Discuss ways to correct mistakes and make changes with your instructor.

WORKMANSHIP

_____ Are the correct fasteners used?

_____ Are carriage bolts used for fastening wood to metal and wood to wood with flat washers?

_____ Are machine bolts used for fastening metal to metal with lock washers?

_____ Were screws used instead of nails?

_____ Was glue used for added strength of wood to wood fastening?

_____ Was fastener size appropriate?

_____ Are all holes deburred?

_____ Are cut edges deburred?

_____ Are exposed pipe ends plugged to prevent water or dirt from entering?

If the project is to be used for livestock:

_____ Were nails used in the project?
_____ Do sharp corners exist?
_____ Do weak members exist (floors, walls, ramps)?
_____ Are wood floors without knots?
_____ Are bolt tips cut and filed to nut?

_____ Are pipe threads exposed? No threads should be exposed.

_____ Is rebar used? Rod should be used rather than rebar.

_____ Are parts that pivot, hinge, or rotate easily replaced if necessary? Bolts are easier to remove than welds.

_____ Are cotter pins and locking pins used appropriately?

_____ Are castle nuts and cotter pins used on wheel bearings?

_____ Are measurements accurate?

_____ Are parts cut with accuracy for best possible fit?

_____ Do parts fit well together for optimum strength?

_____ Are axles aligned properly?

_____ Is the project square and straight?

WELDS

_____ Were appropriate electrodes used?

_____ Was correct position used in welding?

_____ Was travel direction of electrode utilized?

_____ Are both sides of the stock welded when appropriate (strength)?

_____ Was stock 1/4 inch and greater beveled?

_____ Are weld beads porous?

_____ Are there slag inclusions in welds?

_____ Do any cracks exist in the welds?

_____ Was slag removed from weld?

_____ Was spatter removed from weld area?

_____ Do beads have good starting and stopping points?

_____ If gas metal arc welding (GMAW), also known as Metal Inert Gas Welding (MIG), was used, were whiskers removed?

DESIGN

_____ Are unlike metals touching each other?

_____ Were crimps and folds used to increase sheet metal panel strength?

_____ Were dowels and splines used to increase wood strength?

_____ Was tongue and groove joints used to increase wood strength?

_____ Were proper materials selected for construction?

_____ Is there adequate bracing and reinforcement?

_____ Is there ample clearance from tires to fenders?

_____ Are axles properly sized for loads?

_____ Are tires properly sized for loads?

_____ Is the project well-balanced, proportional, and pleasing to the eye?

SUITABILITY

_____ Is the project the correct size for its use?

_____ Is the project suitable for the purpose it was built?

_____ Is the project salable? (Is it good enough to sell?)

_____ Is the project clean and presentable?

SAFETY

_____ Was design based on a tested plan?

_____ Do all wheel lugs have nuts?

_____ Are tires properly mounted?

_____ Are wheel bearings greased?

_____ Were extra strength and sized materials used when safety was a factor?

_____ Is there adequate lighting if the project is to be transported on the road?

_____ Does the project meet legal specifications in width, height, weight, and length?

_____ Is wiring adequate and safe?

FINISH

_____ Was the project primed?

_____ Was the project painted?

_____ Is paint job of high quality: no runs, no drips, no errors?

_____ Was wood properly preserved?

_____ Was suitable paint used?

_____ Was suitable preservative used?

_____ Is the project clean and presentable?

UNIT VI - PROJECT CONSTRUCTION

Lesson 11: Performing Assembly Procedures

Objective: The student will be able to assemble his or her project to the best of his or her abilities.

Study Questions

1. How are layout and cutting related to assembly of a project?
2. How does proper planning aid in assembly?
3. How is distortion controlled when assembling a project?
4. What should be considered when selecting proper fasteners?
5. When are the different types of fasteners used in agricultural construction?
6. What results when dissimilar metals are fastened together?

References

1. Handout
   a) HO 11.1: Performing Assembly Procedures

UNIT VI - PROJECT CONSTRUCTION

Lesson 11: Performing Assembly Procedures

TEACHING PROCEDURES

A. Review

Review the previous lesson involving the identification and correction of defects. Emphasize the reasons for quality control and the satisfaction resulting from a high-quality project.

B. Motivation

Using photographs or real projects, compare how assembly techniques influence the final project. Proper assembly makes construction relatively easy. Speed is not the first requirement. A high level of skill and accuracy are the qualities sought.

C. Assignment

D. Supervised study

E. Discussion

1. Show students samples of poor and accurate cuts and measurements of stock. Ask how these may affect assembly of a project. Include considerations of time, effort, and materials.

   How are layout and cutting related to assembly of a project?

   a) The builder has already thought through the assembly.
   b) The builder has all materials ready for construction.
   c) A high degree of accuracy in layout and cutting makes assembly faster and easier.

2. Some projects may be accomplished without a written plan; but even an unwritten plan aids the builder. Ask students to devise a plan for a common task such as playing baseball, changing oil in a vehicle, or feeding livestock. What items and order of steps are required to accomplish the task?

   How does proper planning aid in assembly?

   a) A logical sequence of assembly is secured.
   b) The builder is familiar with the project and knows what to expect.
   c) Needed tools and equipment are known.
   d) Needed materials and supplies are known.
   e) The need for fixtures is known.
   f) The timing and need for helpers is known.
   g) Power tool use can be maximized.

3. Show students how metal is distorted when heated. Ask students how distortion might be controlled. How can parts be kept aligned and square to each other?

How is distortion controlled when assembling a project?

a) Clamps
b) Prepositioning of parts
c) Tack welding

4. Bring in samples of fasteners. Ask students to identify those typically used in agricultural construction. Demonstrate effective uses of fasteners.

What should be considered when selecting proper fasteners?

a) Material types to be fastened
b) Thickness of material to be fastened
c) Strength of fastener
d) Use of the part being fastened
e) Cost

5. Discuss with students the different fasteners used in agricultural construction. The instructor could provide sample fasteners.

When are the different types of fasteners used in agricultural construction?

a) Carriage bolts - wood to wood; wood to metal
b) Machine bolts - heavy metal to metal
c) Sheet metal screws - thin metal
d) Rivets - metal to metal

6. Bring in samples of how dissimilar metals cause corrosion.

What results when dissimilar metals are fastened together?

a) Galvanic action occurs, causing corrosion.
b) Assembly weakens over time.

F. Other activities

1. Make a photo story of a student and his or her project. Take pictures during all phases of project construction.

2. Visit a local metal shop or factory that builds items. Notice how products are planned and assembled. Discuss how students may use some of the business's ideas in efficiency.

G. Conclusion

Assembly of the product takes skill and knowledge. One must be well prepared for efficient assembly and be able to skillfully construct the project.

H. Competency

Perform assembly procedures.

I. Answers to Evaluation

1. c
2. e
3. c
4. a
5. c
6. e
7. d
8. a
9. e
10. c

Name _____

Lesson 11: Performing Assembly Procedures

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. A high degree of accuracy in laying out and cutting material for a project makes assembly _____.

   a. More difficult
   b. Less organized
   c. Less difficult
   d. Slower
   e. Hitch free

2. Proper planning by the builder helps in a project's assembly and involves the planning of _____.

   a. Tools and equipment to be used
   b. Time needed
   c. Fixtures needed
   d. Materials and supplies to be used
   e. All of the above

3. Distortion during the welding process for a project can be controlled by _____.

   a. Quick cooling
   b. Lower amperage
   c. Tack welding parts
   d. Fastener selection
   e. Using galvanized metal

4. Which fastener is best used for fastening wood to metal?

   a. Carriage bolt
   b. Stove bolt
   c. Machine bolt
   d. Pan head screw
   e. Toggle bolt

5. Which fastener is best used to fasten metal to metal?

   a. Lag screw
   b. Toggle bolt
   c. Machine bolt
   d. Flat head screw
   e. Cotter pin

6. Over-tightening of a sheet metal screw causes _____.

   a. Sweating of metal
   b. Bugling
   c. Buckling
   d. Galvanic action
   e. Stripping of metal or screw

7. To debur a hole means to _____.

   a. Make hole larger than needed
   b. Counter-sink the hole
   c. Ream and thread
   d. Remove any metal from the hole's edge
   e. Taper the hole

8. When fastening dissimilar metals, _____.

   a. Corrosion may occur
   b. Deburring occurs
   c. Spot welding will not work
   d. One metal strengthens the other
   e. Rivets should not be used

9. Which fastener is not recommended for projects to be used with or around livestock?

   a. Rivets
   b. Lag screws
   c. Glue
   d. Flat head screws
   e. Nails

10. A lock washer should be used with which type of fastener?

   a. Carriage bolt
   b. Lag screw
   c. Machine bolt
   d. Toggle bolt
   e. Butterfly nut

Relationship Between Layout and Cutting and Assembly

In assembling a project, it is assumed that all stock has been accurately cut to specified dimensions. Proper layout and cutting are related to assembly in that the builder has already thought through the assembly and has all materials ready for construction. A high degree of accuracy in layout and cutting means faster and easier assembly of the project.

Assembly begins with the project plan. A logical sequence of assembly is necessary so each step is complemented by the preceding step and, in turn, makes ready for the next step.

Advantages of Proper Planning

Proper planning aids in assembly. With thorough planning, the builder is familiar with the project and knows what to expect. Planning helps the builder determine necessary tools and equipment, materials and supplies, fixtures, and the timing and need for helpers. Proper planning also helps the builder maximize the use of power tools for efficient fabrication.

Control of Distortion

Distortion can be controlled and minimized by clamping, prepositioning, and tack welding parts. Clamping aids in minimizing distortion by holding parts securely. Prepositioning of parts compensates for movement due to heat build-up and expansion of metal. Proper tack welding allows for squaring and aligning of parts. Changes can be made with little difficulty after tack welding. When all parts are suitably square and accurate, welding may be completed.

Selection of Fasteners

Fastener selection is based on the type of materials to be fastened, the thickness of materials, the size and strength of fastener needed, and the use of the part being fastened. Cost may also be a factor in fastener selection.

Types of Fasteners

Carriage bolts are used to fasten wood to wood or wood to metal. Carriage bolts are used where a smooth surface is desired. Flat washers should be used with carriage bolts. The square neck of the carriage bolt is pulled into the wood and holds the bolt as the nut is tightened.

When carriage bolts are not suitable for fastening wood to wood, screws are recommended. Nails are not recommended, especially for projects to be used with livestock. Gluing increases fastening strength when wood is fastened to wood.

When fastening metal to metal, a variety of fasteners are available. The fastener that is best suited for the job should be selected. Heavy metal stock should be fastened to metal with machine bolts. Only those machine bolts with fine threads should be torqued. Lock washers are recommended for use with machine bolts.

Sheet metal screws are used to fasten thin pieces of stock. Make sure the sharp ends of the screws are not exposed. Shank holes should be drilled in the first piece of metal and pilot holes should be drilled in the second piece. After alignment, screws may be tightened snugly. Do not overtighten, or stripping of the metal or screw will result.

Rivets are useful in fastening metal to metal. There are a variety of rivet types and sizes available for use. The proper-sized rivet should be selected. After aligning pieces, holes are drilled and rivets attached. When drilling holes for fasteners, always debur the holes jagged pieces of metal not removed by the drill. Deburring improves the workmanship of the project and reduces the chance of being cut by sharp edges on the metal.

Problems of Fastening Dissimilar Metals

Avoid fastening dissimilar metals. Galvanic action of dissimilar metals causes corrosion, which weakens the assembly over time. The builder should be aware of both fastener and stock differences.

UNIT VI - PROJECT CONSTRUCTION

Lesson 12: Reasons for a Project to Have a Finish

Objective: The student will be able to describe why a project should have a finish.

Study Questions

1. What investments are involved in painting or preserving a project?
2. What are the advantages of having a project with a finish?
3. How do painting and preserving extend the useful life of a wood or metal project?

References

1. Handout
   a) HO 12.1: Finishing a Project

UNIT VI - PROJECT CONSTRUCTION

Lesson 12: Reasons for a Project to Have a Finish

TEACHING PROCEDURES

A. Review

Review the previous lesson on assembly procedures. Painting lessons in the "Agricultural Mechanics" unit of the Agricultural Science I and II curriculums should also be reviewed. Emphasize the importance of proper assembly and its influence on the finished product.

B. Motivation

Compare two projects, one with a finish and the other without. Point out that a coat of paint does not cover errors but does make an end product more appealing to the eye. Discuss different projects and the need for a preserving finish.

C. Assignment

D. Supervised study

E. Discussion

1. Anything worth doing involves a degree of investment. Ask students to describe what investments are needed to accomplish a goal. Give examples of how time, money, and effort are involved.

   What investments are involved in painting or preserving a project?

   a) Equipment cost
      1) Air compressor, spray gun, safety equipment
      2) Brush
   b) Supply cost
      1) Metal conditioner (if needed)
      2) Primer
      3) Paint
      4) Thinner
   c) Time and labor costs
      1) Preparation
      2) Painting
      3) Cleanup

2. Show students pictures of two similar houses. One house is painted, but the other still needs to be painted. Have students estimate the value of the selling price of each house if all else is equal. How much would painting each house cost? Is painting worth the investment?

   What are the advantages of having a project with a finish?

   a) Gives product longer useful life than a project without a finish
   b) Makes product more likely to be appealing to the eye
   c) Makes product worth more to the seller

d) Adds salable quality to the project
e) Adds to project's exhibiting quality
f) Is easy to clean

3. Bring in pieces of unpainted or unpreserved wood that have been destroyed due to insects, bacteria, fungus, or moisture. Discuss the life of a project and how preserving and painting are worth the investment. Discuss different types of preservatives and their uses.

How do painting and preserving extend the useful life of a wood or metal project?

a) For wood projects - Preserving and painting extends the life of wood and reduces rotting by prohibiting the following:
   1) Insect infestation
   2) Moisture entry
   3) Bacterial and fungal infestation
b) For metal projects - Painting prohibits entry of moisture which causes corrosion.

F. Other activities

1. Construct a portable spray booth that could be used on projects in the shop.

2. Make a display of all equipment and supplies needed for spray painting.

3. Recondition and paint equipment in the shop.

4. Visit an autobody shop to view how spray painting is accomplished. Point out preparation, painting, and cleanup methods.

G. Conclusion

Painting or preserving is a worthwhile investment for agricultural implements and structures. A high quality finish is recommended for every project being constructed.

H. Competency

Describe why a project should have a finish.

I. Answers to Evaluation

1. a
2. a
3. b
4. b
5. a
6. cost of equipment, cost of supplies, and cost of time and labor

Name _____

Lesson 12: Safety Procedures for Project Construction

Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. A finished project has a longer useful life than a project without a finish.

   a. True
   b. False

2. Painted projects are usually more appealing to the eye.

   a. True
   b. False

3. Painting metal will reduce the tendency of the metal to rot.

   a. True
   b. False

4. There is very little investment in painting and preserving a project.

   a. True
   b. False

5. Finished projects are often easier to clean.

   a. True
   b. False

Complete the following short answer question.

6. What are three types of investment involved in painting or preserving a project?

   a.

   b.

   c.

Investments in Painting or Preserving a Project

A high-quality finish is recommended for all projects constructed. The painting or preserving of a project involves a certain amount of investment but is well worth it. The investment of painting involves the cost of equipment, supplies, and time and labor.

Equipment for spray painting includes an air compressor, spray gun, respirator, goggles, and gloves. Brush painting requires brushes, of course.

Supplies necessary for painting or preserving a project include metal conditioner for metal projects and primer, paint, and thinner for either metal or wood projects.

The cost of the time involved is often labeled as labor cost. Time is needed to properly prepare the surface, paint the project, and clean up the equipment and work area.

Advantages of a Project with a Finish

There are many advantages in painting and preserving a project. A project with a finish has a longer useful life than a project without a finish. A painted project is more likely to be appealing to the eye. A project that is finished properly will be worth more to the seller. A finished product adds to the project's exhibiting qualities. A project to be displayed or used to compete at the county or state fair should have a high-quality finish. A finished project also allows for easy cleaning.

Extension of the Useful Life of a Finished Project

The useful life of a project is extended by applying a preservative or paint covering. A preservative or paint covering prevents the infestation of insects, fungus, or bacteria, and the entry of moisture in wood objects. Both infestation and moisture cause rotting, which shortens the life of an implement or structure. In metals, painting prohibits the entry of moisture which will result in corrosion.

The time spent in proper preservation is much less than the time needed for reconstruction and replacement. In the long run, painting or preserving is a smart investment.

UNIT VI - PROJECT CONSTRUCTION

Lesson 13: Determining the Actual Cost of Materials and Labor for Individual Projects

Objective: The student will be able to determine actual cost of materials and labor for the project.

References

1. Worksheet

   a) WS 13.1: Actual Cost of Materials and Labor

UNIT VI - PROJECT CONSTRUCTION

Lesson 13: Determining the Actual Cost of Materials and Labor for Individual Projects

TEACHING PROCEDURES

A. Review

Review the previous lesson on the importance of painting and preserving. Emphasize to students the advantages of a finished project.

B. Motivation

Obtain photographs and prices for equipment sold by a local implement dealer. Compare the cost of newly manufactured equipment with products constructed in class. Compare workmanship, quality, use, and suitability.

C. Assignment

Using WS 13.1, have students keep a running record of the actual cost of constructing their individual projects from start to finish. Costs will include materials and labor. The form may be kept in the student's notebook or on a clipboard or bulletin board for easy access and visibility.

D. Supervised study

E. Discussion

Discuss labor costs and the worth of student labor as apprentices. Set a reasonable wage to be used in calculating labor costs. Use these figures to project the labor costs on WS 13.1.

F. Other activities

1. Compare the quality and total cost of several students' projects.

G. Conclusion

In finishing the project, the student should have an accurate account of the cost for constructing the project. The cost of materials can be used to verify payment of materials purchased. The total material and labor cost can be used to calculate the estimated value of the project.

H. Competency

Determine actual cost of materials and labor for project.

I. Evaluation

Mastery level of the competency is based on grades given on WS 13.1.

STUDENT'S NAME _____

PROJECT TITLE _____

Date started _____

Date completed _____

ACTUAL COST OF MATERIALS AND LABOR

No. of Pieces	Material	Dimensions	Part	Unit Cost	Cost	Hours of Work for Individual Project	
						Week No.	Hours

_____
(Teacher's Signature)

Total Material Cost _____ Total Hours _____

_____
(Student's Signature)

Total Labor Cost = _____ (total hrs.) × _____ (cost/hr.) = _____

_____
(Parent's Signature)

GRAND TOTAL COST OF CONSTRUCTION = _____
(Total Material Cost + Total Labor Cost)

UNIT VI - PROJECT CONSTRUCTION

Lesson 14: Hand and Power Tools

Objective: The student will be able to safely use all tools needed for completing his or her individual project.

Reference

1. Work Sheet

   a) WS 14.1: Hand and Power Tools Used in Completing a Project

UNIT VI - PROJECT CONSTRUCTION

Lesson 14: Hand and Power Tools

TEACHING PROCEDURES

A. Review

Review the previous lesson on figuring cost of materials and labor. Emphasize the need for accurate records in figuring total cost of a project.

B. Motivation

Set up a mock interview between teacher and student. Acting as a prospective employer, ask the student about his or her tool use experience. Prospective employers viewing the student's competency sheet can see the list of tools and equipment the student is competent in using.

C. Assignment

Have students keep a running record of all tools and equipment used in the construction of their projects. At a later date, this list will be useful to students in setting up their own shops or in purchasing desired tools or equipment. Records may be kept in student notebooks or on a clipboard or bulletin board. Record keeping can quickly be achieved daily after cleanup.

D. Supervised study

E. Discussion

Prospective employers may need to know what tools and equipment each student is experienced in using. Discuss the use of the tool list (WS 14.1) with students.

F. Other activities

1. Have students make a display for underclassmen of tools needed for construction of a certain project.

2. Take photographs of individual students with their projects and all the tools they used in completing their projects. These photographs could make the basis for a good newspaper story that would let townspeople know what is accomplished in the shop at school.

G. Conclusion

Competence in tool usage is important for students desiring work in agricultural mechanics or related fields.

H. Competency

Use hand and power tools in completing a project.

I. Evaluation

The work sheet should be completed by students. On the competency sheet, the teacher should rate the student on mastery level use of individual hand and power tools listed on the work sheet.

HAND AND POWER TOOLS USED IN COMPLETING A PROJECT WS 14.1

STUDENT'S NAME _____

PROJECT TITLE _____

HAND TOOLS USED	POWER TOOLS USED	
NAME	NAME	SIZE

The following are suggestions for proper actions to be taken in case of an accident in the agricultural education shop. No specific order is implied since situations will vary.

* Assess the situation.
  - Don't panic. Check for broken bones, bleeding, and signs of shock.
  - If possible, do not move the student. Apply appropriate first aid.
* Send another student for help.
* Notify the school nurse, administration, and parents of the student.
* If medical treatment is necessary, secure supervision for the class and accompany the student to the hospital to explain events and actions taken.
* Document the incident that day.
  - Fill in accident report form explaining time, date, and events.
  - Take pictures of the area and damages.
  - Provide documentation of safety instruction given to the student.
  - Provide documentation of any special warnings or instructions given to the student before the accident occurred that could have prevented it.

NOTE: If the school does not have an accident report form, the instructor could complete the "Standard Student Accident Report Form" found in Appendix B. Instructions for completing the form are found at the bottom of this page.

Please Read Carefully **INSTRUCTIONS** **Fill in Completely**

A. Use Part **A** of the form to report any accident to a student at any place (home, school or elsewhere) any time of the day or night.

B. Use Part **B** of the form to report additional information about accidents to students while under school jurisdiction.

☐ Place an "X" in the box at the upper right-hand of the form for an accident sufficiently serious to require a doctor's care or to keep a child out of school one-half day or more. Only such accidents should be included in your annual summary to the National Safety Council.

IMPORTANT: In order that maximum use be made of accident reports, it is essential that the accident be described in sufficient detail to show the unsafe acts and unsafe conditions existing when the accident occurred. The description should answer such questions as: What was the student doing at the time of the accident? (Playing tag or football, operating lathe, cutting lawn, etc.) Was he using any apparatus, machine, vehicle, tool or equipment? How was he using it? Would it have been safer to do it some other way? Was another person involved in the accident in any way?

For further information see "What You Should Know About Standard Student Accident Reporting."

STANDARD STUDENT ACCIDENT REPORT FORM

Part A. Report ALL accidents to Students Occurring Anywhere, Day or Night

1. Name: _____ Home Address: _____
2. School: _____ Sex: M ☐; F ☐. Age: ____ Grade or classification: _____
3. Time accident occurred: Hour _____ A.M.; _____ P.M. Date: _____
4. Place of Accident: School Building ☐ School Grounds ☐ To or from School ☐ Home ☐ Elsewhere ☐

5. NATURE OF INJURY

Abrasion	____	Fracture	____
Amputation	____	Laceration	____
Asphyxiation	____	Poisoning	____
Bite	____	Puncture	____
Bruise	____	Scalds	____
Burn	____	Scratches	____
Concussion	____	Shock (el.)	____
Cut	____	Sprain	____
Dislocation	____		

Other (specify) _____

PART OF BODY INJURED

Abdomen	____	Foot	____
Ankle	____	Hand	____
Arm	____	Head	____
Back	____	Knee	____
Chest	____	Leg	____
Ear	____	Mouth	____
Elbow	____	Nose	____
Eye	____	Scalp	____
Face	____	Tooth	____
Finger	____	Wrist	____

Other (specify) _____

DESCRIPTION OF THE ACCIDENT

How did accident happen? What was student doing? Where was student? List specifically unsafe acts and unsafe conditions existing. Specify any tool, machine or equipment involved. _____

6. Degree of Injury: Death ☐ Permanent Impairment ☐ Temporary Disability ☐ Nondisabling ☐
7. Total number of days lost from school: _____ (To be filled in when student returns to school)

Part B. Additional Information on School Jurisdiction Accidents

8. Teacher in charge when accident occurred (Enter name): _____
   Present at scene of accident: No: _____ Yes: _____

9. IMMEDIATE ACTION TAKEN

First-aid treatment	____	By (Name): _____
Sent to school nurse	____	By (Name): _____
Sent home	____	By (Name): _____
Sent to physician	____	By (Name): _____
		Physician's Name: _____
Sent to hospital	____	By (Name): _____
		Name of hospital: _____

10. Was a parent or other individual notified? No:__ Yes:__ When:_____ How: _____
    Name of individual notified: _____
    By whom? (Enter name) _____
11. Witnesses: 1. Name: _____ Address: _____
    2. Name: _____ Address: _____

12. LOCATION

	Specify Activity		Specify Activity
Athletic field	_____	Locker	_____
Auditorium	_____	Pool	_____
Cafeteria	_____	Sch. grounds	_____
Classroom	_____	_____ shop	_____
Corridor	_____	Showers	_____
Dressing room	_____	Stairs	_____
Gymnasium	_____	Toilets and washrooms	_____
Home Econ.	_____		
Laboratories	_____	Other (specify)	_____

Remarks

What recommendations do you have for preventing other accidents of this type? _____

Signed: Principal: _____ Teacher: _____

(National Safety Council—Form School 1) Rep. Printed in U.S.A. Stock No. 429.21

TRAILER AXLE PLACEMENT PROGRAM

APPENDIX C

by Dale Ratcliff
California, MO

MS-DOS (IBM) Version
Radio Shack Model 4 Version
Radio Shack Model 3 Version
Apple Version

```
10 KEY OFF:DIM BC(30),PC(30),L(30),H(30):CLS
20 LOCATE 1,10:PRINT"Trailer Axle Placement & Load Distribution Program"
30 LOCATE 2,10:PRINT"-----------------------------------------------------"
40 LOCATE 4,5:PRINT"The only information you will need to know to operate this program is:"
50 LOCATE 6,10:PRINT"1) The overall length of the bed of your trailer"
60 LOCATE 8,10:PRINT"2) The length of the tongue from the front of the trailer to the hitch"
70 LOCATE 10,10:PRINT"3) Either the"
80 LOCATE 12,13:PRINT"total maximum load to be hauled OR"
90 LOCATE 13,13:PRINT"total maximum hitch weight of the trailer"
100 LOCATE 15,10:PRINT"4) and if the trailer is a Bumper Hitch or a Gooseneck."
110 LOCATE 17,10:PRINT"*************************************************************"
120 LOCATE 18,10:PRINT"** Program Written By:  Dale L. Ratcliff, California, MO **"
130 LOCATE 19,10:PRINT"*************************************************************"
140 LOCATE 21,28:PRINT"Press Enter to Continue ";
150 IF INKEY$="" THEN 150 ELSE CLS
160 LOCATE 2,1:LINE INPUT"Enter the length of the bed of your trailer (in feet).   ";AD$:AD=VAL (AD$)
170 LOCATE 4,1:LINE INPUT"Enter the length of the hitch of your trailer (in feet). ";DE$:DE=VAL (DE$)
180 LOCATE 6,1:PRINT"Please enter a MAXIMUM Weight for either the total load or":LOCATE 7,1:LINE INPUT"the total
hitch weight   --> ";L$:L=VAL(L$)
190 LOCATE 9,1:PRINT"Was this value for (L)oad or (H)itch Weight ";
200 GOSUB 720:L$=Z$:PRINT L$:IF L$="L" THEN TY=1 ELSE IF L$="H" THEN TY=2 ELSE TY=0:GOTO 200
210 IF TY=2 THEN H=L
220 LOCATE 11,1:PRINT"Is this a (B)umper Hitch or (G)ooseneck Trailer ";
230 GOSUB 720:T$=Z$:PRINT T$:IF T$="B" THEN 240 ELSE IF T$="G" THEN 240 ELSE 230
240 LOCATE 21,1:PRINT"Is all of the data correct (Y/N) ";
250 GOSUB 720:IF Z$="Y" THEN 260 ELSE IF Z$="N" THEN CLS:GOTO 160 ELSE 250
260 IF T$="B" THEN 270 ELSE IF T$="G" THEN 280
270 X=0:P1=.1:P2=.12:GOTO 290
280 X=0:P1=.18:P2=.25:GOTO 290
290 CE=(AD/2)+DE
300 Y=P1
310 Z=1-Y:X=X+1
320 BC(X)=CE*Y/Z:PC(X)=Y*100
330 Y=Y+.0025:IF Y>P2 THEN 340 ELSE 310
340 CLS:GOSUB 350:GOTO 390
350 IF TY=1 THEN TYP$="Gooseneck" ELSE TYP$="Bumper Hitch"
360 TIL$=" Trailer - Axle Placement & Load Distribution Table"
370 TIM$="Trailer   ..... Tongue ..... Axle Placement   Maximum Total":TIN$=" Length   Length  % Weight
   # Weight    Feet  Inches   Load - Pounds":TIO$=STRING$(70,"=")
```

```
380 PS$= "   ##.#    ##.#'    ##.##%     ##,###   ##.##' ###.##''     ##,###":PT$="                    ##.##%
 ##,###   ##.##' ###.##''     ##,###":RETURN
390 LOCATE 15,1:PRINT"Do you want to see the data on the Video Screen (Y/N) ";
400 GOSUB 720:IF Z$="Y" THEN 410 ELSE IF Z$="N" THEN 540 ELSE 390
410 GOSUB 420:GOTO 430
420 CLS:LOCATE 1,6:PRINT TYP$;TIL$:LOCATE 2,1:PRINT TIM$:LOCATE 3,1:PRINT TIN$:LOCATE 4,1:PRINT TIO$:CT=0:RETURN
430 FOR Y=1 TO X
440 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 460
450 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
460 IF CT>0 THEN 480
470 PRINT USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 490
480 PRINT USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
490 IF CT=>15 THEN 500 ELSE 520
500 GOSUB 730
510 GOSUB 420
520 NEXT Y
530 GOSUB 730
540 CLS
550 LOCATE 15,1:PRINT"Do you want a printed copy of the data (Y/N) ";
560 GOSUB 720:IF Z$="Y" THEN 600 ELSE IF Z$="N" THEN 570 ELSE 560
570 CLS:LOCATE 15,1:PRINT"Do you want to run the program again (Y/N) ";
580 GOSUB 720:IF Z$="Y" THEN CLS:GOTO 160 ELSE IF Z$="N" THEN 590 ELSE 580
590 CLS:END
600 CLS
610 LPRINT" ":LPRINT" ":LPRINT TAB(8) TYP$;TIL$:LPRINT" ":LPRINT TAB(5)TIM$:LPRINT TAB(5)TIN$:LPRINT TAB(5)TIO$:C
T=0
620 LOCATE 15,1:PRINT"........  Printing your data .......";
630 FOR Y=1 TO X
640 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 660
650 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
660 IF CT>0 THEN 680
670 LPRINT TAB(5)USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 690
680 LPRINT TAB(5)USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
690 NEXT Y
700 LPRINT CHR$(12)
710 CLS:GOTO 570
720 Z$=INKEY$:IF Z$="" THEN 720 ELSE Z$=CHR$(ASC(Z$)AND &H5F):RETURN
730 LOCATE 21,1:PRINT"Press Enter to Continue ";
740 IF INKEY$="" THEN 740 ELSE RETURN
```

```
10 CLEAR 5000:DIM BC(30),PC(30),L(30),H(30):CLS
20 PRINT@(0,9),"Trailer Axle Placement & Load Distribution Program"
30 PRINT@(1,9),"-----------------------------------------------"
40 PRINT@(3,5),"The only information you will need to know to operate this program is:"
50 PRINT@(5,9),"1) The overall length of the bed of your trailer"
60 PRINT@(7,9),"2) The length of the tongue from the front of the trailer to the hitch"
70 PRINT@(9,9),"3) Either the"
80 PRINT@(10,12),"total maximum load to be hauled OR"
90 PRINT@(11,12),"total maximum hitch weight of the trailer"
100 PRINT@(13,9),"4) and if the trailer is a Bumper Hitch or a Gooseneck."
110 PRINT@(15,9),"*************************************************************"
120 PRINT@(16,9),"** Program Written By:  Dale L. Ratcliff, California, MO **"
130 PRINT@(17,9),"*************************************************************"
140 PRINT@(20,0),"Press Enter to Continue ";
150 IF INKEY$="" THEN 150 ELSE CLS
160 PRINT@(0,0),"Enter the length of the bed of your trailer (in feet).   ";:LINE INPUT AD$:AD=VAL(AD$)
170 PRINT@(2,0),"Enter the length of the hitch of your trailer (in feet). ";:LINE INPUT DE$:DE=VAL(DE$)
180 PRINT@(4,0),"Please enter a MAXIMUM Weight for either the total load or":PRINT@(5,0),"the total hitch weight
  --> ";:LINE INPUT L$:L=VAL(L$)
190 PRINT@(7,0),"Was this value for (L)oad or (H)itch Weight ";
200 GOSUB 720:L$=Z$:PRINT L$:IF L$="L" THEN TY=1 ELSE IF L$="H" THEN TY=2 ELSE TY=0:GOTO 200
210 IF TY=2 THEN H=L
220 PRINT@(9,0),"Is this a (B)umper Hitch or (G)ooseneck Trailer ";
230 GOSUB 720:T$=Z$:PRINT T$:IF T$="B" THEN 240 ELSE IF T$="G" THEN 240 ELSE 230
240 PRINT@(20,0),"Is all of the data correct (Y/N) ";
250 GOSUB 720:IF Z$="Y" THEN 260 ELSE IF Z$="N" THEN CLS:GOTO 150 ELSE 250
260 IF T$="B" THEN 270 ELSE IF T$="G" THEN 280
270 X=0:P1=.1:P2=.12:GOTO 290
280 X=0:P1=.18:P2=.25:GOTO 290
290 CE=(AD/2)+DE
300 Y=P1
310 Z=1-Y:X=X+1
320 BC(X)=CE*Y/Z:PC(X)=Y*100
330 Y=Y+.0025:IF Y>P2 THEN 340 ELSE 310
340 CLS:GOSUB 350:GOTO 390
350 IF TY=1 THEN TYP$="Gooseneck" ELSE TYP$="Bumper Hitch"
360 TIL$=" Trailer - Axle Placement & Load Distribution Table"
370 TIM$="Trailer   ..... Tongue .....  Axle Placement   Maximum Total":TIN$=" Length   Length  % Weight
  # Weight    Feet  Inches   Load - Pounds":TIO$=STRING$(70,"=")
```

```
380 PS$= "   ##.#    ##.#'    ##.##%     ##,###   ##.##' ###.##''     ##,###":PT$="                    ##.##%
 ##,###   ##.##' ###.##''     ##,###":RETURN
390 PRINT@(15,0),"Do you want to see the data on the Video Screen (Y/N) ";
400 GOSUB 720:IF Z$="Y" THEN 410 ELSE IF Z$="N" THEN 540 ELSE 390
410 GOSUB 420:GOTO 430
420 CLS:PRINT TAB(6) TYP$;TIL$:PRINT" ":PRINT TIM$:PRINT TIN$:PRINT TIO$:CT=0:RETURN
430 FOR Y=1 TO X
440 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 460
450 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
460 IF CT>0 THEN 480
470 PRINT USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 490
480 PRINT USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
490 IF CT=>15 THEN 500 ELSE 520
500 GOSUB 730
510 GOSUB 420
520 NEXT Y
530 GOSUB 730
540 CLS
550 PRINT@(15,0),"Do you want a printed copy of the data (Y/N) ";
560 GOSUB 720:IF Z$="Y" THEN 600 ELSE IF Z$="N" THEN 570 ELSE 560
570 CLS:PRINT@(15,0),"Do you want to run the program again (Y/N) ";
580 GOSUB 720:IF Z$="Y" THEN CLS:GOTO 160 ELSE IF Z$="N" THEN 590 ELSE 580
590 CLS:END
600 CLS
610 LPRINT" ":LPRINT" ":LPRINT TAB(8) TYP$;TIL$:LPRINT" ":LPRINT TAB(5)TIM$:LPRINT TAB(5)TIN$:LPRINT TAB(5)TIO$:C
T=0
620 PRINT@(15,10),"........  Printing your data .......";
630 FOR Y=1 TO X
640 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 660
650 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
660 IF CT>0 THEN 680
670 LPRINT TAB(5)USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 690
680 LPRINT TAB(5)USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
690 NEXT Y
700 LPRINT CHR$(12)
710 CLS:GOTO 570
720 Z$=INKEY$:IF Z$="" THEN 720 ELSE Z$=CHR$(ASC(Z$)AND &H5F):RETURN
730 PRINT@(22,1),"Press Enter to Continue ";
740 IF INKEY$="" THEN 740 ELSE RETURN
```

```
10 CLEAR 5000:DIM BC(30),PC(30),L(30),H(30):CLS
20 PRINT@1,"Trailer Axle Placement & Load Distribution Program"
30 PRINT@65,"-----------------------------------------------------"
40 PRINT@192,"The only info. needed to operate this program is:"
50 PRINT@256,"1) The overall length of the bed of your trailer"
60 PRINT@320,"2) The length of the tongue from the front of the trailer"
65 PRINT@387,"to the hitch "
70 PRINT@448,"3) Either the"
80 PRINT@515,"total maximum load to be hauled OR"
90 PRINT@579,"total maximum hitch weight of the trailer"
100 PRINT@640,"4) and if the trailer is a Bumper Hitch or a Gooseneck."
110 PRINT@768,"*************************************************************"
120 PRINT@832,"** Program Written By:  Dale L. Ratcliff, California, MD **"
130 PRINT@896,"*************************************************************"
140 PRINT@960,"Press Enter to Continue ";
150 IF INKEY$="" THEN 150 ELSE CLS
160 PRINT@0,"Enter the lenght of the bed of your trailer (in feet).   ";:LINE INPUT AD$:AD=VAL(AD$)
170 PRINT@128,"Enter the length of the hitch of your trailer (in feet).  ";:LINE INPUT DE$:DE=VAL(DE$)
180 PRINT@256,"Please enter a MAXIMUM Weight for either the total load or":PRINT@320,"the total hitch weight   —
> ";:LINE INPUT L$:L=VAL(L$)
190 PRINT@448,"Was this value for (L)oad or (H)itch Weight ";
200 GOSUB 720:L$=Z$:PRINT L$:IF L$="L" THEN TY=1 ELSE IF L$="H" THEN TY=2 ELSE TY=0:GOTO 200
210 IF TY=2 THEN H=L
220 PRINT@576,"Is this a (B)umper Hitch or (G)ooseneck Trailer ";
230 GOSUB 720:T$=Z$:PRINT T$:IF T$="B" THEN 240 ELSE IF T$="G" THEN 240 ELSE 230
240 PRINT@896,"Is all of the data correct (Y/N) ";
250 GOSUB 720:IF Z$="Y" THEN CLS:GOTO 260 ELSE IF Z$="N" THEN CLS:GOTO 160 ELSE 250
260 PRINT@330,"..... CALCULATING THE DATA .......";:IF T$="B" THEN 270 ELSE IF T$="G" THEN 280
270 X=0:P1=.1:P2=.12:GOTO 290
280 X=0:P1=.18:P2=.25:GOTO 290
290 CE=(AD/2)+DE
300 Y=P1
310 Z=1-Y:X=X+1
320 BC(X)=CE*Y/Z:PC(X)=Y*100
330 Y=Y+.0025:IF Y>P2 THEN 340 ELSE 310
340 CLS:GOSUB 350:GOTO 390
350 IF TY=1 THEN TY$="Gooseneck" ELSE TY$="Bumper Hitch"
360 TL$=" Trailer - Axle Placement & Load Distribution Table"
370 TM$="Trailer ..... Tongue ..... Axle Placement  Max. Total":TN$=" Length Length % Weight  # Weight
Feet  Inches   Load - Lbs":TI$=STRING$(62,"=")
```

```
380 PS$= "   ##.#   ##.#'   ##.##%    ##,###  ##.##' ###.##''  ##,###":PT$="                    ##.##%     ##,###
  ##.##' ###.##''  ##,###":RETURN
390 PRINT@384,"Do you want to see the data on the Video Screen (Y/N) ";
400 GOSUB 720:IF Z$="Y" THEN 410 ELSE IF Z$="N" THEN 540 ELSE 390
410 GOSUB 420:GOTO 430
420 CLS:PRINT TY$;TL$:PRINT " ":PRINT TM$:PRINT TN$:PRINT TI$:CT=0:RETURN
430 FOR Y=1 TO X
440 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 460
450 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
460 IF CT>0 THEN 480
470 PRINT USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 490
480 PRINT USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
490 IF CT=>10 THEN 500 ELSE 520
500 GOSUB 730
510 GOSUB 420
520 NEXT Y
530 GOSUB 730
540 CLS
550 PRINT@384,"Do you want a printed copy of the data (Y/N) ";
560 GOSUB 720:IF Z$="Y" THEN 600 ELSE IF Z$="N" THEN 570 ELSE 560
570 CLS:PRINT@384,"Do you want to run the program again (Y/N) ";
580 GOSUB 720:IF Z$="Y" THEN CLS:GOTO 160 ELSE IF Z$="N" THEN 590 ELSE 580
590 CLS:END
600 CLS
610 LPRINT" ":LPRINT" ":LPRINT TAB(5) TY$;TL$:LPRINT" ":LPRINT TAB(5)TM$:LPRINT TAB(5)TN$:LPRINT TAB(5)TI$:CT=0
620 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT"........  Printing your data .......";
630 FOR Y=1 TO X
640 IF TY=1 THEN L(Y)=L:H(Y)=L*BC(Y)/(BC(Y)+(AD/2)+DE):GOTO 660
650 IF TY=2 THEN H(Y)=L:L(Y)=H*(BC(Y)+(AD/2)+DE)/BC(Y)
660 IF CT>0 THEN 680
670 LPRINT TAB(5)USING PS$;AD;DE;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1:GOTO 690
680 LPRINT TAB(5)USING PT$;PC(Y);H(Y);BC(Y);(BC(Y)*12);L(Y):CT=CT+1
690 NEXT Y
700 LPRINT CHR$(12)
710 CLS:GOTO 570
720 Z$=INKEY$:IF Z$="" THEN 720 ELSE Z$=CHR$(ASC(Z$)AND &H5F):RETURN
730 PRINT@960,"Press Enter to Continue ";
740 IF INKEY$="" THEN 740 ELSE RETURN
```

The filename is --> TRAILERA.BAS
Trailer Axle Placement Program - Apple Version

```
10 HOME
20 DIM BC(30),PC(30),L(30),H(30)
30 PRINT TAB(7)"Trailer Axle Placement & "
40 PRINT TAB(7)"Load Distribution Program"
50 PRINT TAB(7)"-------------------------"
60 PRINT:PRINT"The only information you will need "
70 PRINT"to know to operate this program is:"
80 PRINT:PRINT"1) The overall length of the bed of"
90 PRINT"your trailer,  2) the length of the"
100 PRINT"tongue from the front of the trailer "
110 PRINT"to the hitch,  3) Either the total"
120 PRINT"maximum load to be hauled OR total"
130 PRINT"maximum hitch weight of the trailer,"
140 PRINT"4) and if the trailer is a Bumper"
150 PRINT"Hitch or a Gooseneck."
160 PRINT:PRINT"****************************************"
170 PRINT"**       Program Written By:          **"
180 PRINT"** Dale L. Ratcliff, California, MO  **"
190 PRINT"****************************************"
200 PRINT:INPUT"Press Enter to Continue ";Z$
210 ED=0
220 HOME
230 PRINT:PRINT"Enter the length of the bed of your"
240 INPUT"trailer (in feet).   ";AD
250 PRINT:PRINT"Enter the length of the hitch of your"
260 INPUT"trailer (in feet).   ";DE
270 PRINT:PRINT"Please enter a MAXIMUM Weight for"
280 PRINT"either the total load or the total"
290 INPUT"weight.                ";L
300 PRINT:PRINT"Was this value for (L)oad or (H)itch"
310 INPUT"Weight (L/H)           ";L$
320 IF L$="L" THEN TY=1:GOTO 370
330 IF L$="l" THEN TY=1:L$="L":GOTO 370
340 IF L$="H" THEN TY=2:GOTO 370
350 IF L$="h" THEN TY=2:L$="H":GOTO 370
360 TY=0:GOTO 220
370 IF TY=2 THEN H=L
380 PRINT:PRINT"Is this a (B)umper Hitch or (G)ooseneck"
390 INPUT"trailer (B/G)          ";T$
```

```
400 If T$="B" THEN GOTO 450
410 IF T$="b" THEN T$="B" :GOTO 450
420 IF T$="G" THEN GOTO 450
430 IF T$="g" THEN T$="G" :GOTO 450
440 GOTO 220
450 PRINT:PRINT"Is all of the data correct (Y/N)  ";
460 INPUT Z$:IF Z$="Y" THEN GOTO 500
470 IF Z$="y" THEN GOTO 500
480 IF Z$="N" THEN GOTO 230
490 IF Z$="n" THEN GOTO 230
500 HOME:PRINT"..... Calculating your data ..... ";
510 IF T$="B" THEN GOTO 540
520 IF T$="b" THEN GOTO 540
530 GOTO 550
540 X=0:P1=.1:P2=.12:GOTO 560
550 X=0:P1=.18:P2=.25:GOTO 560
560 CE=(AD/2)+DE
570 Y=P1
580 Z=1-Y:X=X+1
590 BC(X)=INT(CE*Y/Z*100):BC(X)=BC(X)/100:PC(X)=INT(Y*10000):PC(X)=PC(X)/100
600 Y=Y+.0025:IF Y>P2 THEN GOTO 620
610 GOTO 580
620 HOME
630 GOSUB 640:GOTO 710
640 IF TY=1 THEN TYP$="Gooseneck" ELSE TYP$="Bumper Hitch"
650 TIL$="Trailer - Axle Placement &"
660 TIL1$=" Load Distribution Table"
670 TIM$="..... Tongue .... Axle Plac. Max Total"
680 TIN$="% Weight  # Weight    Feet  Load - Lbs."
690 TIO$="═══════════════════════════════════════"
700 RETURN
710 HOME
720 PRINT"Do you want to see the data on the":PRINT"Video Screen (Y/N) ";
730 IF Z$="Y" THEN GOTO 780
740 IF Z$="y" THEN GOTO 780
750 IF Z$="N" THEN GOTO 900
760 IF Z$="n" THEN GOTO 900
770 GOTO 710
780 GOSUB 790:GOTO 810
```

The filename is --> TRAILERA.BAS

Trailer Axle Placement Program - Apple Version

```
790 HOME
800 PRINT TYP$;" ";TIL$:PRINT TAB(8)TIL1$:PRINT" ":PRINT TIM$:PRINT TIN$:PRINT TIO$:CT=0:RETUR
810 FOR Y=1 TO X
820 IF TY=1 THEN L(Y)=INT(L):H(Y)=INT(L*BC(Y)/(BC(Y)+(AD/2)+DE)):GOTO 840
830 IF TY=2 THEN H(Y)=INT(L):L(Y)=INT(H*(BC(Y)+(AD/2)+DE)/BC(Y))
840 PRINT TAB(2)PC(Y);TAB(11);H(Y);TAB(22);BC(Y);TAB(31);L(Y):CT=CT+1
850 IF CT=>10 THEN 860 ELSE 880
860 PRINT"Trailer Length -> ";AD:PRINT"Hitch Length -> ";DE:GOSUB 1160
870 GOSUB 790
880 NEXT Y
890 GOSUB 1160
900 HOME
910 PRINT"Do you want a printed copy of the"
920 INPUT"data (Y/N) ";
930 IF Z$="Y" THEN GOTO 1070
940 IF Z$="y" THEN GOTO 1070
950 IF Z$="N" THEN GOTO 980
960 IF Z$="n" THEN GOTO 980
970 GOTO 900
980 HOME
990 PRINT"Do you want to run the program"
1000 INPUT"again (Y/N) ";
1010 IF Z$="Y" THEN GOTO 220
1020 IF Z$="y" THEN GOTO 220
1030 IF Z$="N" THEN GOTO 1060
1040 IF Z$="n" THEN GOTO 1060
1050 GOTO 980
1060 HOME:END
1070 HOME
1080 PR#1
1090 PRINT TYP$;" ";TIL$:PRINT TAB(8)TIL1$:PRINT"  ":PRINT TIM$:PRINT TIN$:PRINT TIO$
1100 FOR Y=1 TO X
1110 IF TY=1 THEN L(Y)=INT(L):H(Y)=INT(L*BC(Y)/(BC(Y)+(AD/2)+DE)):GOTO 1130
1120 IF TY=2 THEN H(Y)=INT(L):L(Y)=INT(H*(BC(Y)+(AD/2)+DE)/BC(Y))
1130 PRINT TAB(2)PC(Y);TAB(11);H(Y);TAB(22);BC(Y);TAB(31);L(Y)
1140 NEXT Y
1150 PR#0:HOME:GOTO 980
1160 PRINT:PRINT:INPUT"Press Enter to Continue ";Z$
1170 RETURN
```